COMMERCIAL CHICKEN PRODUCTION MANUAL

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COMMERCIAL CHICKEN PRODUCTION MANUAL

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WESTPORT, CONNECTICUT
THE AVI PUBLISHING COMPANY, INC.
1972

Library of Congress Catalog Card Number 72-78911
ISBN-0-87055-119-1

Printed in the United States of America

Preface

This Manual covers every phase of poultry management. The incentive to write it arose from the fact that a great share of the success of a present-day poultry enterprise rests with the people involved with management—actual poultry caretakers, hatcherymen, servicemen, and supervisors. Although the principles of poultry production may be condensed into a short set of rules, the variation in the behavior of chickens under actual field conditions is tremendous, and these rules would not always apply. Seemingly, no two flocks are alike.

Each day the poultryman is called upon to make decisions that will alter his management program. The weather changes, stresses appear, feed consumption is down, eggshell quality is poor, birds are too heavy, disease strikes, hatchability drops, chick quality is poor, or feed conversions are not good. These are but a small number of the problems that arise to necessitate a quick solution. The planned program of management must be altered. It is the author's intent that this book provide guides for these decisions so as to help improve the conditions within the poultry house or hatchery, thereby increasing the profitability of the operations.

Realizing that prevention is better than a cure, the Manual has been written so that management programs may be developed that will aid in alleviating many production problems. Subject background material has been reduced to include only the more pertinent information, and an endeavor has been made to keep it practical. This will give the poultryman a better understanding of the many recommendations made throughout the book.

The absence of photographs will be obvious. But it was thought that the page area could best be devoted to text, as other poultry books and periodicals provide an abundant and current supply of pictures.

There is some repetition, inasmuch as almost any subject discussed entails reference to some other subject. Furthermore, thought had to be given to those who will not read the entire book, but will have need for only one section or one chapter at a time. To prevent as much repetition as possible, cross-references are given.

A large proportion of the discussions are the result of experience of poultry producers in the field who keep their chickens under commercial conditions. But in all cases, experimental results have been reviewed and many quoted, and proper source credit given. However, no attempt has been made to present a subject bibliography nor to summarize the experimental work on any particular detail.

Although the book has been prepared as a service manual and reference guide, it has great value as a text for those courses dealing with practical field poultry production. To be of use to as many as possible, figures are given in both the English and metric systems.

MACK O. NORTH

Contents

Modern Breeds of Chickens

Through the years a large number of breeds and varieties of chickens has been developed, but most of these are of historical interest. Relatively few have survived commercialism in the poultry industry to be used by poultry breeders today. Many of these early breeds have been eliminated, to be lost to the poultry industry forever; others have been retained by a few breeders interested in developing uncommon varieties. Some are maintained by government breeding stations so that these varieties will be available to commercial and other breeders if the need arises. These *gene pools* are an important part of a program to maintain certain characteristics found in the obscure breeds. Geneticists do not want to lose these genes forever, which would be the case if all the rare breeds ceased to exist.

BREEDS OF CHICKENS USED TODAY

In the early days of the commercial poultry industry, most of the chicks sold represented pure breeds or varieties. Breeding practices at that time were confined to improving the economic potential of these pure lines. Gradually, however, two or more breeds were crossed to improve their productivity. Eventually, particularly in the case of those birds bred for the production of meat, new *synthetic lines* were developed. Although many pure breeds were incorporated in their production, these new synthetics did not represent any former breed or variety. They were new and different. Geneticists continue to experiment with many such new synthetics; many more are being developed today.

Most of the breeds and varieties of chickens used in today's breeding programs, or used to develop synthetic lines, are included in the following list.

New Hampshire

The New Hampshire was developed from the Rhode Island Red by breeding it for high egg production, good hatchability, and other factors. The color of the feathers is much lighter than that of the Rhode Island Red. The New Hampshire has yellow skin, a single comb, and produces a light-brown egg. When first established it was known for its egg production, but later it became recognized as a bird with excellent meat qualities. For several years it was the leading breed for the production of broiler chicks. Later, the New Hampshire females were crossed with males of another variety to produce crossbred broiler chicks.

Although the New Hampshire still is used by some breeders of meat-type poultry, the number is few. The bird has become almost extinct, as a result of poor growth of the broiler offspring and the dark pinfeathers and hair, which made it difficult to pick the broilers in the processing plant.

The New Hampshire has, however, been used in developing many of the synthetic meat-type lines of chickens, and still is used for this purpose. Its ability to produce a large number of eggs that hatch well has made it a valuable asset to many breeding combinations.

White Plymouth Rock

The White Plymouth Rock has been used for the production of meat-producing strains For years it was the predominant pure line bird used for broiler production in the United States Later, it became an important one in other countries In some instances this variety was mated with the Light Sussex to produce a broiler chick with white skin

The White Plymouth Rock has a single comb, yellow skin, and lays a brown egg It possesses genes for rapid growth and excellent feed conversion Its feather color is *recessive white*, and the white feathers made it particularly applicable to broiler production when commercial poultry processing plants came into existence These plants did a better job of picking chickens with white feathers Most original strains of White Plymouth Rocks were genetically *slow feathering* However, many strains have been developed that are *fast feathering*

Cornish

Cornish chickens have pea combs, lay a brown egg, and have yellow skin They have a body type very different from most other of the early breeds The legs are short, the body is broad, and the breast is very wide and muscular There are several varieties, such as the Dark Cornish with a greenish black feather color mingled with gold, the White Cornish with pure white feathers, and the White-Laced Red Cornish, sometimes known as the Light Cornish, with light red feathers laced with dark white

The Cornish features were desirable from a meat standpoint, but the birds laid but a few small eggs with poor hatchability In order to utilize their meat qualities Cornish males were crossed with females from such breeds as the Barred Plymouth Rock, New Hampshire, and White Plymouth Rock These three breeds represented female lines that produced a larger number of eggs that hatched well The Cornish male became known as the *male line* as it was used only on the male side of the final mating Several breeders established male lines, mostly from the Light Cornish, and these breeders became known as *meat type male line breeders* Those breeding the female lines were *meat type, female line breeders*

Soon the demand for broilers with white feathers increased, and gradually the meat type, male-line breeders brought out new synthetic lines of males that were Cornish type, but had white feathers. Not only were they white, but when bred to females with colored feathers, the offspring had white or nearly white feathers Although the original White Cornish variety was genetically *recessive white*, these new lines were *dominant white* No doubt the dominant white gene was incorporated by mating some variety of Cornish with the White Leghorn which also carried the dominant white gene The new lines lost their identity as Cornish, and such lines became known as *dominant white male lines*

Although some pure breeds, such as the White Plymouth Rock, still make up the male side of the mating used to produce commercial broiler chicks, the number has been decreasing very rapidly each year Today, most broiler chicks are sired by a male from a dominant white male line

Single Comb Rhode Island Red

This variety has a long, block like body, single comb, and lays a brown egg It has yellow skin and the feathers are red with some black in the tail, hackle, and

wings. Several years ago, many strains of this variety were in existence, most of which were excellent egg producers. Few were used for meat production.

But during the last few years the Rhode Island Red has taken on a new value. When a male of this breed is mated with a female that is genetically silver or barred, it is possible to determine the sex of the day-old chicks by differences in the color of the chick down. Today a good many of the commercial brown-egg layers are the result of crossing special strains of Rhode Island Reds and Barred Plymouth Rocks. The offspring are excellent producers of large brown eggs.

Barred Plymouth Rock

One of the most popular of the early breeds of poultry was the Barred Plymouth Rock. Known as a *dual-purpose breed* it produced a goodly number of eggs, and because of its relatively large size it produced a fairly large quantity of meat. The Barred Plymouth Rock was an excellent "farm" chicken, and was popular with small farmers who kept a few birds; it provided both eggs and meat.

The Barred Plymouth Rock has feathers covered with bars of white and black running crosswise, giving the bird a gray appearance. It has a single comb, yellow skin, and lays a brown egg.

As the demand for eggs increased, the consumer showed a preference for eggs with white shells rather than brown. And as commercial production of white eggs increased, the Barred Plymouth Rock dropped in popularity. However in some countries there is a demand for eggs with brown shells. Although the Barred Plymouth Rock is not used to fulfill this requirement, females from the breed are mated with Rhode Island Red males to produce a hybrid pullet laying a large number of eggs with brown shells. Day-old chicks from the above cross may be *autosexed*, because the males and females have different down colors. The autosexing feature has helped make the cross popular.

Some 20 to 30 years ago special strains of Barred Plymouth Rocks were developed for use in the broiler industry. Males from these specialized strains were mated with New Hampshire or Rhode Island Red females. The females were good egg producers; the males contributed a lot to broiler size and type. Broilers from these matings were known as *Rock-Red cross broilers*. However, the dark-colored feathers and black pinfeathers in the broilers made them difficult to pick, and the Barred Rock male gave way to males of the new dominant white male lines just developed.

Light Sussex

The Sussex is predominantly a British breed with several varieties; the Light Sussex is the most popular. It has white skin, lays a brown egg, and is a good meat producer. It is used in parent matings for the production of broiler chicks with white skin. When the Sussex is crossed with varieties having yellow skin, the offspring have white skin. This makes it possible to use present-day broiler strains of chickens for the female side of the mating, taking advantage of the qualities developed in them, yet using the Sussex on the male side to produce the white skin.

Light Brahma

The Light Brahma has yellow skin, pea comb, and lays a brown egg, all of value to a meat-type strain. It has a columbian plumage pattern, the same as the Rhode

Island Red However, the Rhode Island Red is gold or red with some black in the neck and tail, while the Light Brahma is white (genetically silver) with black But it has feathers on its legs and this is detrimental to a good meat-type broiler strain The Light Brahma has not been a predominant progenitor of modern meat lines

Australorp

The Australorp was developed from the Black Orpington which produced brown eggs Produced in Australia, the Australorp was bred to produce eggs with a tinted color, and at one time it held a commanding position in the commercial egg field It has white skin and a single comb, is much smaller than its predecessor, and is an excellent egg producer

Single Comb White Leghorn

This is one of several varieties of Leghorns, and is the only one that has survived the era beginning with the demand for commercial white eggs Practically all the egg producing strains of chickens are Single Comb White Leghorns This bird, as bred today, is small compared with other breeds, has a single comb and yellow skin, and produces chalk white eggs Although but one variety is used, there are many strains in existence, each breeder using a *closed flock*, highly in bred, to produce the desired characteristics in his strain or strains Some strains have special qualities, such as

- large eggs
- disease resistance
- small body weight
- better interior egg quality
- better shell quality
- tinted eggshell color
- others

Strain crosses used Many of the commercial Leghorn pullets being produced today are the result of crossing two or more lines of Single Comb White Leghorns This increases heterosis and allows the breeder to select for certain genetic traits in each of the lines

Imbred line crosses Some breeders have resorted to inbreeding within certain lines by mating brothers and sisters for several generations After several years of inbreeding, two or more of the inbred lines are crossed to produce a commercial pullet

EGG PRODUCTION LINES

Egg production lines are those used to produce commercial egg type pullets for the production of commercial eggs The lines involve those that produce white eggs and those that produce brown eggs

White Egg Lines

Most of these lines are Single Comb White Leghorns Some of the lines are pure, that is, they are not involved with strain crossing Others are the product of crossing two or more strains of the same variety

Single line The breeder usually uses a *closed flock*, continually selecting the better birds in each generation and breeding from them Only a small percentage of the better birds are used in the matings Normally, the

TABLE 1.1

CHARACTERISTICS OF SOME BREEDS OF CHICKENS USED TODAY

Breed	Plumage Color	Earlobe Color	Skin Color	Under-color	Comb Type	Mature Body Weight Male Lb	Kg	Female Lb	Kg	Eggshell Color
White Leghorn	white	white	yellow	white	single	5.7	2.59	4.2	1.91	white
White Plymouth Rock	white	red	yellow	white	single	9.5	4.31	7.5	3.40	brown
New Hampshire	red	red	yellow	buff	single	7.5	3.40	6	2.72	brown
White Cornish	white	red	yellow	white	pea	10	4.54	8	3.63	brown
Dark Cornish	greenish-black	red	yellow	dark slate	pea	10	4.54	8	3.63	brown
Rhode Island Red	red	red	yellow	buff	single	8	3.63	6.2	2.81	brown
Barred Plymouth Rock	barred	red	yellow	slate	single	8	3.63	6.2	2.81	brown
Light Sussex	black and white	red	white	white	single	9.5	4.31	7.5	3.40	brown
Light Brahma	black and white	red	yellow	white	pea	10	4.54	8	3.63	brown
Australorp	black	red	white	black	single	7.5	3.40	5.5	2.50	tinted

pullets are kept in egg production for a year in order to measure several factors responsible for economic production of quality eggs. Selection of the best birds is made at the end of the first year of egg production. Many features will enter into the selection, such as:

body weight	egg weight
growth rate	egg production
growing livability	eggshell quality
pullet quality	interior quality of eggs
age at sexual maturity	adult livability

Strain crosses: Rather than select for all outstanding qualities within a single line many breeders resort to a technique of selecting for but a few qualities in a line. Another line will involve selection for other qualities. Sometimes as many as four lines are used. Two or more lines are then crossed in order that the resulting offspring will inherit all the necessary qualities, part coming from the male parent, and part from the female parent. An example of a two-line cross would be as follows:

Male line	*Female line*
Bred for:	Bred for:
livability	egg production
large body size	shell quality
egg size	interior egg quality

Although there may be several other factors involved with each line, the above listing represents the major ones. When the two lines are crossed, the resulting pullets would be used for the production of com-

mercial eggs, these pullets would have

- good livability
- relatively large body size
- good egg size
- good egg production
- good shell quality
- good interior egg quality

Three way cross Three lines are developed, each with different qualities Two lines are crossed, and the offspring from these two are crossed with the third line Although additional lines generally add to the cost of producing the commercial pullets, the advantages may outweigh the additional expense

Four way cross Four lines are developed Two of the four lines are crossed, then the remaining two The offspring from each cross are mated together to produce the commercial pullet

Strains used for crossing must nick When two lines of chickens complement each other they are said to *nick* The poultry breeder will develop many lines of egg laying strains and will mate many of them together Some crosses will give improved results, others will not In other words, some lines will nick, some will not Those that do nick will be used as the basis for the production of the commercial pullets In this way it also is possible to develop commercial birds that excel in only one or two particular traits For example, the breeder might develop a com mercial pullet that lays an exceptionally large egg Another pullet, the result of a different cross, would live unusually well In these cases, the nickability is especially involved with one particular trait

Brown Egg Lines

Several breeders have developed special lines or crosses for the production of commercial birds that lay eggs with brown shells In some instances two breeds or varieties have been used to make the cross Not only do the offspring lay brown eggs, but the chicks may be *sexed* at one day of age by color differentiation

	Male line		*Female line*
Breed	Rhode Island Red	Breed	Barred Plymouth Rock

When a Rhode Island Red male is crossed with a Barred Plymouth Rock female the offspring male chicks are black with a white head spot, the female chicks are almost black Thus, this cross makes it possible to sex the chicks at hatching time according to color Special egg producing lines of Rhode Island Reds and Barred Plymouth Rocks that nick are used to make the cross

In other instances other varieties are mated together to produce offspring that will lay eggs with brown shells Sometimes the chicks from these crosses can be sexed at hatching time, in others, they cannot

MEAT PRODUCTION LINES

Certain varieties and lines of chickens have been bred for the production of meat rather than eggs This means that their offspring are capable of producing rapid and economic gains when raised for broilers or roasters Furthermore, they attain heavy weights at marketable age

Genetically, it is impossible to breed a single line of chickens that will produce both eggs and meat. The breeding program must go one way or the other. When birds are selected for high egg production their ability to produce meat is lessened. Opposed to this is the fact that when birds are selected for the fast growth and good feed conversion necessary for meat production, the ability to lay a large number of eggs decreases. Thus, meat lines do not lay as well as egg lines.

Female Meat Lines

During the early production of specialized meat lines the same variety of chicken was used for both the male and female side of the mating. Many times the male and female came from the same line. Later, the breeders specialized in developing lines necessary for either the male side or the female side of the mating. Thus, those developing the females were known as *meat-line female breeders*. As the females of the mating lay the eggs and are responsible for the hatchability of the eggs, these female lines were bred to produce a fairly large number of eggs that hatched well, yet the birds were large and had good growth-promoting characteristics. They were truly meat lines, and the genetic programs used in their development concentrated on their meat potentialities.

Male Meat Lines

While some breeders were developing the female meat lines others were producing male meat lines. These breeders became known as *meat line male breeders*.

Barred Plymouth Rock meat lines. The birds developed by the male line breeders had exceptionally heavy fleshing, they were large, grew rapidly, and had good feed conversion (ability to convert feed to meat efficiently). Several breeders or varieties were used, but the first of consequence was the Barred Plymouth Rock. Strains were bred for increased size and other qualities necessary for the production of poultry meat. As growth in the line increased, the number of eggs produced and the hatchability decreased. The larger the bird became, the fewer the eggs and the lower the hatchability. Egg size also decreased. These differences have been observed in other male meat lines that were developed later.

At the time the Barred Plymouth Rock male meat lines were so popular such males were mated with females from female meat lines developed from varieties such as the Rhode Island Red and New Hampshire. The offspring commercial broiler chicks showed great potentialities for the production of broiler meat, developing fast and economically.

Cornish meat lines. Some time later meat-type male lines were developed from the Dark Cornish and the Light Cornish. Males from these lines were mated with females from the female meat lines. But males from both the Barred Plymouth Rock and Cornish lines when bred to these female lines produced broiler chicks with dark feathers. These broilers would not pick clean with automatic poultry processing equipment, dark-colored pin feathers and hairs would be left on the body.

White feathered meat lines. When the meat-type female breeders developed birds with white feathers, there came a demand for males with white feathers. White Plymouth Rock males were used first. Soon the synthetic male lines with white feathers were developed. Most of these not only had white feathers, but when crossed with colored females the off-

spring had white or nearly white feathers This was a decided benefit, and during the course of a few years most male lines possessed genes for feathering of this type Genetically, the birds are known as *dominant white* Today, practically all meat-type male lines are of this type.

THE PACKAGE DEAL

Until rather recently the breeders of meat lines confined their efforts to the production of either males or females Today, however, many of the meat-line breeders, but not all, produce both the male and female lines In such cases the *primary breeder* sells both the cockerel and pullet day-old chicks as a *package deal* in which the customer is supplied from 12 to 15 cockerel chicks with every 100 female chicks The same poultry breeder supplies both lines However, some of the larger meat type breeders still produce but one line, either the male or the female line, the customer selects his female chicks and his male chicks from the breeder of his choice

Single primary breeders of white-egg and brown-egg type lines of birds have, almost without exception, bred all the lines needed for the production of the commercial egg type pullet This has been necessary because of the intricate methods of making the matings to produce the males and females Only certain combinations will nick Therefore, male and female egg type breeder parents always come from the same breeder, and are shipped to the customer as a package deal usually in the ratio of 10 to 12 males for every 100 females

BREEDS USED FOR ROASTER PRODUCTION

Roaster chickens are usually those young meat type chickens whose live weight is 5 lb (2 27 kg) or over Generally the weights are heavier than this at the present time, as many broilers have attained a 4-lb live weight when they are marketed at 9 or 10 weeks of age Many roasters will show a live weight of 6 or 7 lb (2 72–3 18 kg) when they are sold

Roasters command a special price when sold, higher than that received for broilers As it costs more per pound to produce a roaster than it does a broiler, the extra added value is well deserved, and necessary for the producer to make a profit

Specialized strains of meat type roaster birds have been developed that are capable of producing these desired weights in a minimum of time, and economically Because the difference between the weight of the roaster male and roaster female is so great at market time when both sexes are reared together, many such birds are sexed at day old, and the sexes raised separately This enables the producer to sell the males at 6 to 7 lb (2 72–3 18 kg), and then keep the females about 10 days longer, or until they reach similar weight

THE MINI-BREEDS

During the past several months several strains of *mini chickens* have appeared on the market These birds are not to be confused with the bantams originated many years ago Dwarfism in mini breeds is due to a six linked, recessive gene, *dw* However, the gene behaves differently in meat lines than in egg lines These differences may be detailed as follows

Dwarfism in Mini-Leghorns

Dwarfism in mini-Leghorn females shows the following when compared with normal birds:

(1) The birds are 20 to 25% lighter at 8 weeks of age, and 30 to 35% lighter at 25 to 30 weeks of age.
(2) They have shorter legs.
(3) Yolk accumulation in the ovary is reduced.
(4) Egg production is reduced from 15 to 20%.
(5) Egg weight is reduced by 5%.
(6) They eat less feed per dozen eggs produced than do normal birds.

Important: Mini-Leghorns are smaller and require less floor space in the poultry house or in the cage, allowing more birds to be housed in a given area. Also, they require less feed to produce a dozen eggs. However, there are economic disadvantages in the production of mini-Leghorns. They produce fewer eggs that are smaller in size. Because of the small size of the birds their carcass value at the end of the laying year is very small; sometimes they are of no value.

Considering the advantages and the disadvantages, the mini-Leghorn has not been able to take the place of Leghorns of conventional size. The economics are not satisfactory. Results are highly variable when measured on return per dollar invested, but the mini-birds generally show a lower return than normal birds.

Dwarfism in the Mini-Meat Strains

Compared with normal birds, the mini-meat strains show:

(1) Females lay the same number of eggs. Although yolk accumulation is reduced, it is adequate to meet the demand of the oviduct for ova.
(2) Broiler chicks grow at a lower rate. Female broilers from mini-mothers are 0.15 to 0.20 lb (68.0–90.7 gm) lighter. Straight-run broilers from mini-mothers are about 0.10 lb (45.4 gm) lighter.

Important: From the standpoint of the broiler mother, she may be used efficiently, as she produces eggs at a normal rate and at a reduced *unit* cost since feed and overhead costs are less. However, the lower growth rate of the broilers raises the cost per pound of bird. This is a decided disadvantage, and it is doubtful that this increase can be offset by any reduction in the cost of producing the hatching eggs.

THE RANDOM SAMPLE TESTS

In many areas of the world various strains of chickens are tested under some type of government supervision and control. Breeders enter their birds in these contests where many genetic and economic traits are measured. At the end of each contest the various lines are ranked according to some predefined formula, and the results published. There are two types of contests.

Random Sample Broiler Tests

A few years ago certain contests were instigated to appraise the growth, feed conversion, body conformation, carcass quality, and livability of commercial

broilers These were *random sample tests*, in which an impartial person would select a required number of hatching eggs at *random* from those produced by the person entering the contest In this way the sample consisted of eggs representative of those being offered for sale, rather than of eggs that had been selected from a few choice individuals The eggs were incubated, and the broiler chicks hatched from each entry were placed in a separate pen and raised to marketable age

Most of these broiler growing tests have been abandoned because of lack of interest, but some still are in existence Reports of the results of the various birds entered in these contests are published after completion

Random Sample Egg Laying Tests

In a manner similar to the Random Sample Broiler Tests, egg laying tests are conducted Eggs are selected at random from the breeders, the chicks hatched, grown, and placed in pens or cages at sexual maturity Many measurements are taken during the period of egg production, such as number of eggs produced, size, shell quality, interior quality, bird mortality, feed consumption, etc Final results are often measured as "income over feed and chick cost "

Many Random Sample Egg Laying Tests are conducted by government agencies, but the number is not as large as it was a few years ago Not only are the results of these contests of value to the primary breeder as a means of comparing the productivity of his strain with those of other breeders, but they give the customer an opportunity to study the same contest results From such a study he is better able to select a strain of birds that will meet his requirements

Structure of the Chicken

Before discussing commercial chicken production the makeup of the bird should be understood.

Chickens are vertebrates, many of their anatomical structures being adapted for flight. They are warm-blooded, with a high metabolic rate. Chickens (and other birds) have a rapid heart beat, sometimes as much as 300 pulsations a minute. The smaller the bird, the more rapid the beat. The beat is subject to great variation. Often it may double as the result of excitement alone. The chicken has no sweat glands; consequently the bird breathes rapidly to eliminate heat and moisture from its body. The body temperature of the chicken is highly variable. The average is somewhere between 105° and 107°F (40.6°-41.7°C). It is highest shortly after noon; lowest, just before midnight. Broody hens have a lower body temperature than nonbroody hens, probably the result of a lower metabolic rate.

SURFACE OF THE FOWL

The chicken is covered with feathers, skin and scales, the latter being a derivative of reptiles, from which birds evolved. See Figures 2.1 and 2 2.

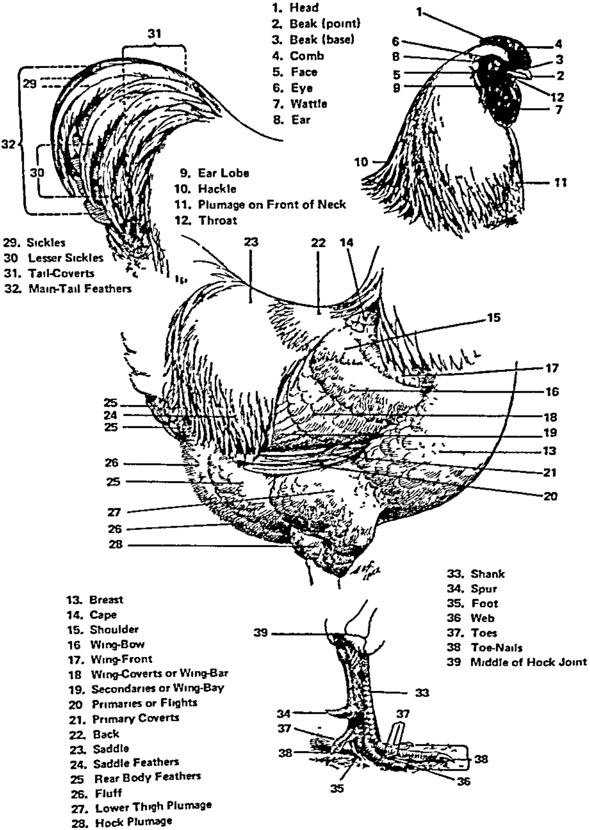
Feathers

The fact that birds are almost completely covered with feathers makes them different from other vertebrates Because feathers wear away, become broken, or are pulled out, nature has provided the bird with a method of renewing its feathers approximately once a year through a process of dropping the remaining feathers, and growing a new set. This procedure is known as *molting* Most chickens do not produce eggs during the molting process, and under commercial poultry production the time of the molt may be manipulated so that the hen will not produce eggs during a certain season. See Chapter 18

The feathers on a chicken vary in size and shape, but all have the following parts·

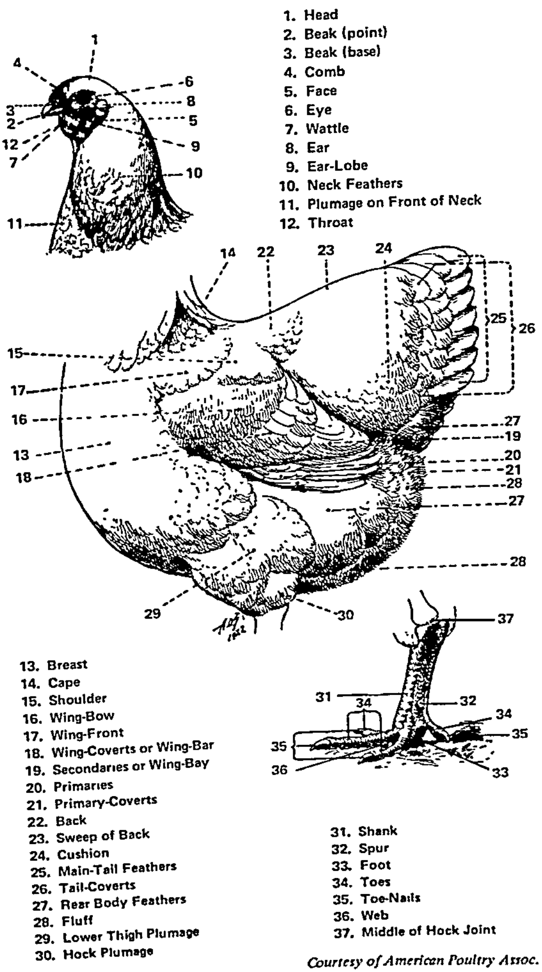
quill	web or surface
shaft	barbs
accessory plume	barbules
fluff or undercolor	barbicels

How the feathers are replenished: When the chick hatches, it has almost no feathers. Except for the wings and tail, it is covered with down. Soon the down grows longer, and most of the particles develop a shaft. Within a few days the shaft erupts, and the web of the feather makes its appearance. By the time the chick is 4 or 5 weeks of age, it has become fully feathered. These first feathers are soon molted, and a new set is grown by the time the bird is 8 weeks old. The third set of feathers is grown by about the 13th week. The fourth set is completed just prior to the time the bird reaches sexual maturity, and is the first mature plumage.



Courtesy of American Poultry Assoc

FIG 2 1 NOMENCLATURE OF MALE



Courtesy of American Poultry Assoc.

FIG. 2.2. NOMENCLATURE OF FEMALE

Feathers are predominantly protein. They make up between 4 and 8% of the live weight of the bird.

Sexual differences in feathers: Hormones play an important part in the shape and size of some feathers They increase the length and narrow the width of certain feathers on the male bird. These are represented by the saddle, hackle, sickle, and lesser sickle feathers.

Feather tracts: Feathers do not cover the body of the bird uniformly, but grow in rows to produce tracts or areas over the body. There are 10 major feather tracts, as follows:

shoulder	abdomen
thigh	leg
rump	back
breast	wing
neck	head

Color of feathers. There are many feather colors and many color patterns on the individual feathers. In many instances there are differences in the color according to the location of the feathers on the body. Feather colors and feather patterns are genetic characteristics, and their inheritance has been worked out by scientists. See Chapters 20 and 21

Head

The head of the chicken is represented by the following parts

Comb. There are several types of combs, but only the first three of the following list are common:

single	strawberry
rose	walnut
pea	"V"
cushion	buttercup

Eyes
Eye-rings
Ears
Earlobes
Wattles
Beak

Feet and Shanks

The shanks and most of the feet are covered with scales Some birds have yellow shanks, some white, some black Yellow color is due to the lipochrome pigment in the epidermis when melanic pigment is absent Varying shades of black are due to the presence of melanic pigment in the epidermis. When there is black in the dermis and yellow in the epidermis, the shank has a greenish appearance When there is complete absence of both types of pigment, the shanks are white. Important parts of the foot and shank are

Hock
Shank
Toes Most chickens have 4 toes on each foot, but there are a few breeds that have 5.

Webs of the toes
Toenails
Spur. More pronounced in the male than in the female.

Skin

Most of the bird is covered with skin common to the type found on mammals However, specialized skin is found in such areas as the comb, wattles, earlobes, and scales. Except for the specialized areas, the color of the skin is either white or yellow. The density of the yellow color is correlated with the amount of xanthophyll in the ration.

INTERIOR OF THE FOWL

Skeleton

The skeleton of the fowl is similar to the skeleton of mammals At least all the bones are present, although some are fused or elongated in the bird Figure 2 3 shows the relationship The wings correspond to the arms and hands of human beings, the legs of the chicken (shanks) contain the same bones as those found in the legs and feet of man The bones of the metatarsus, common to the human hand, have been fused and elongated in the chicken to form the shank. The skeleton is the framework which supports the body and to which the muscles are attached The rib cage protects some of the vital organs

Muscles

Muscles that motivate the wings are important to those birds that fly, and are attached to the keel of the sternum (breastbone) which also supports the vital organs of the abdominal cavity These muscles are especially well developed in most birds Development has increased through genetic selection as evidenced in the modern turkey and meat-type broiler strains of chickens

The rate of flow of blood through the muscles determines their color. The legs are made up of dark meat, and the breast is composed of white meat because a chicken walks more than it flies

The Respiratory System

The respiratory system of the chicken consists of.

nasal cavities	bronchi
pharynx	air sacs
trachea	certain air-containing bones

Compared with mammals, the lungs of the chicken are small, but their breathing is supplemented by the air sacs Birds have four pairs of air sacs, plus one single, the interclavicular sac The paired ones may be divided equally into thoracic and abdominal air sacs. Air moves in and out of the lungs and air sacs freely, but the lungs are responsible for most of the respiration.

Digestive Tract

The important parts of the digestive tract are as follows

Mouth.—The chicken has no lips, cheeks, or teeth, but there are an upper and lower horny mandible to enclose the mouth, the upper being attached to the skull while the lower is hinged. The two mandibles are referred to as the *beak*. As in

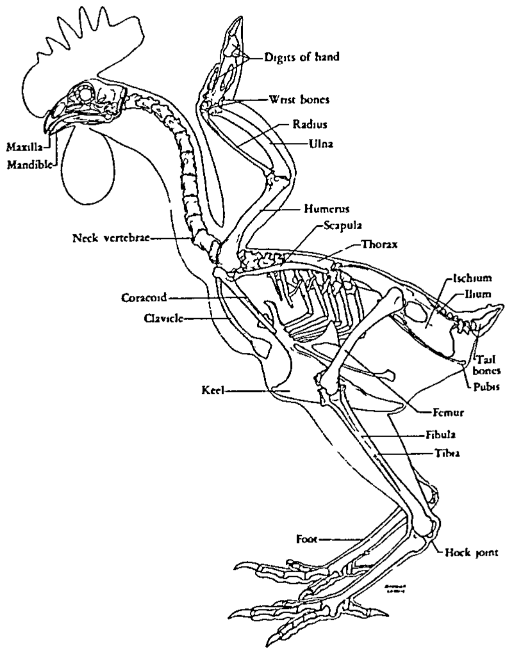


FIG 2 3 THE SKELETON OF A FOWL

the case of mammals, saliva is secreted by glands in the mouth. However, food passes through the mouth quickly so there is little chance for any digestion there.

Esophagus.—The esophagus or gullet is the tube through which food passes from the back of the mouth (pharynx) to the proventriculus.

Crop.—Just before the gullet enters the body cavity it extends into a pouch known as the crop, which acts as a storage place for food. Little or no digestion takes place here except that involved with the salivary secretions of the mouth, which continue their activity in the crop

Proventriculus.—An enlargement of the gullet just prior to its connection with the gizzard is known as the proventriculus or *glandular stomach*. Here, pepsin and

hydrochloric acid are secreted by the glandular cells. Because the food passes quickly through the proventriculus there is no digestion of food material here, but the secretions pass into the gizzard where the digestion takes place.

Gizzard.—The gizzard, sometimes called the *muscular stomach*, lies between the proventriculus and the upper limit of the small intestine. The gizzard remains quiet when empty, but once food enters, the muscular contractions of its thick walls begin. The larger the particles of food, the more rapid the contractions. As the gizzard usually contains some abrasive material, such as rocks, gravel, etc., the food material is soon ground or reduced to small particles capable of being taken into the intestinal tract. When fine material enters the gizzard it leaves in a few minutes, but when the food material is coarse it will remain in the gizzard until it is broken down into fine particles, which may require several hours.

Small Intestine.—The small intestine is about 62 in. (157 cm) long in the average adult chicken. The first part of it forms a loop known as the *duodenal loop* in which most of the intestinal digestion takes place. Imbedded in the loop is the *pancreas*, which secretes pancreatic juice.

Ceca.—Between the small and large intestines two blind pouches are found. These are known as the ceca. Each cecum is about 6 in. (15.2 cm) long in the adult bird, and contains soft food material. The function of the ceca is not fully known, but it can be surgically removed without injury to the health of the bird.

Large Intestine.—The large intestine is relatively short in the chicken, being only 4 or 5 in. (10.2-12.7 cm) long in the adult bird. It extends from the end of the small intestine to the cloaca.

Cloaca.—The bulbous area at the end of the alimentary tract is known as the *cloaca*. Cloaca means "common sewer" and into the cloaca empty the digestive, urinary, and reproductive tracts.

Supplementary Digestive Organs

Pancreas: The pancreas lies within the duodenal loop of the small intestine. It is a gland that secretes pancreatic juice which is then transferred to the small intestines by way of the pancreatic ducts, where it aids in the digestion of starches, fats and proteins.

Liver: The liver is composed of two large lobes. Among other functions, the liver secretes bile, which is transferred to the lower end of the duodenum of the intestinal tract, where it aids digestion.

Gallbladder: Two bile ducts transfer the bile from the liver to the intestines. The right duct enlarges to form the gallbladder, where the bile is temporarily stored. The left duct from the liver does not enlarge; therefore the bile passes through it directly to the small intestine.

Spleen: An accessory digestive organ whose function is not entirely clear.

Reproductive System

The male reproductive system consists of two testicles located in the dorsal area of the body cavity, just in front of the kidneys; the epididymi; the vasa deferentia, or tubes which carry the semen from the testicles to the papillae; and the copulatory organ.

The female reproductive system consists of the ovary and the oviduct. These are described in detail in Chapter 3.

CHANGES DURING EGG PRODUCTION

During the time that female chickens are laying, and during the molt, certain changes occur in the appearance of the bird (1) the yellow coloring material in the skin of yellow skinned chickens decreases, and (2) there is a relationship between the molting process and egg production These relationships have been studied and associated with the number of eggs the bird has laid, along with the time the birds have been out of production because of the molt

The Molt

Egg production is correlated with the season and duration of the molt Many physical factors are associated with egg production, but the molt is the most significant

Generally speaking, birds begin to molt their feathers when egg production ceases The length of the molting period varies In the case of good egg producers, the molt is late in the season, and rapid Poor egg producers molt early and slowly Some of the better layers continue laying eggs after the molt begins, but lay at a relatively slow rate Poor layers molt after a shorter period of egg production, and lose their feathers very slowly

Order of the Molt —The areas of the body in which the feathers are molted follow a definite order and pattern It is this order that offers an indication of the number of eggs produced by the hen prior to the time she stopped laying eggs, and molting started

Body molt The feathers are dropped from the various sections of the body in the following order

(1) head	(4) back	(7) wing
(2) neck	(5) fluff	(8) tail
(3) breast	(6) abdomen	

Many times a flock will go through a partial molt, usually involving the head and neck and a few feathers in the wing, as the result of stress or disease

Parts of the Wing —When the wing of the bird is extended two groups of feathers will be observed, as follows

(a) *Primaries* These are farthest removed from the body, and usually 10 in number
(b) *Secondaries* Normally there are 14 secondary feathers located in the section of the wing closest to the body
(c) *Axial feather* Between the two sections is a single, short feather known as the axial feather

How the Wing Feathers Are Molted —All wing feathers are not molted concurrently If they were, the wing would be devoid of feathers at times and the bird would be unable to fly In the case of the primary feathers, the molt is quite uniform The primary feather closest to the axial feather is the first to be molted The others are molted in regular order to the outside of the wing Consequently, these feathers may be numbered from 1 (next to axial feather) to 10 (next to tip of wing)

Normally, one primary feather is dropped at a time, and it takes approximately 6 weeks for a new feather to grow back in Thus it would take 16 weeks to complete the primary wing molt and to grow all the new feathers to their full length

High egg-producing hens drop two or more feathers at a time: Although most low-producing chickens drop 1 primary feather at a time, birds that produce a large number of eggs may molt 2, 3, or sometimes 4 feathers at a time. This speeds up the molting process, as all ten feathers will be dropped in a shorter period.

Molting pattern indicates time bird has been out of production: By observing the wing of the molting bird it is possible to estimate the length of time she has been out of production.

If the bird is molting in a regular manner, that is, one primary feather per week, the number of molted feathers will be identical with the number of weeks since the bird laid her last egg. If, however, the bird is a rapid molter, dropping more than one primary feather at a time, on occasions, the multiple number would represent a single week in making the computation.

When more than one primary feather is dropped at the same time, the group will grow back at the same rate. This fact makes it easy to make the determination of the number of feathers molted each week.

Partial molt: Occasionally during the laying period, a bird will cease producing eggs because of disease, weather or stress. During this period, the bird will drop one, two, or more primary feathers depending on the length of time the bird is not producing eggs. Number 1 primary feather will be molted first, then number 2, etc. Most of the time the birds will produce eggs again before the feathers have grown back in. At the end of the laying year, when the bird begins her normal year-end molt, she would start her molt where she left off during her period of stress. If she molted primaries numbers 1 and 2 during the middle of the laying year, at the end of the year she would begin her molt with primary feather number 3, then continue until she had dropped number 10, and then follow by molting feathers 1 and 2 again.

Yellow Pigmentation

In chickens with yellow skin, pigmentation color is of value in determining the number of eggs the bird has laid, and the pattern of her egg production.

Yellow color is due to the pigment, xanthophyll, a substance that is easily oxidized from the skin of the bird. Not only is it lost, but there is a pattern of this loss, some areas bleaching more rapidly than others. The order, from the first to the last area bleached, is as follows:

(1) vent (most rapidly bleached)
(2) eye-ring
(3) earlobe
(4) beak (base to tip)
(5) bottom of feet
(6) front of shank
(7) rear of shank
(8) hock and tops of toes

Bleaching.—The word "bleaching" denotes oxidation of the xanthophyll from the tissues of the bird. If the hen is not laying, the amount of xanthophyll in the ration usually will be adequate to replenish the amount in the tissues. However, xanthophyll also is found in egg yolk, giving the yolks their yellow color. When the hen is laying rapidly, most of the xanthophyll from the feed supply goes for the production of yolk pigment; there is little left to replace that in the tissues of

the skin, etc Thus, after a long period of egg production the tissues become bleached to a blue white color

Number of Eggs to Bleach the Various Areas —Although the amount of xanthophyll in the ration determines the density of the yellow color in the skin, there is some correlation between the number of eggs the bird has laid and the areas having, or not having, yellow color The number of eggs necessary to bleach the various sections is as follows

vent		bleached by the time the first egg is laid
eye ring		one or two eggs
earlobes		9 or 10 eggs
beak	inner one third	11 eggs
	inner one half	18 eggs
	inner two thirds	23 eggs
	inner four fifths	29 eggs
	entirely white	35 eggs
bottoms of the feet		66 eggs
front of the shanks		95 eggs
back of the shanks		159 eggs
tops of the toes		175 eggs
hock joints		180 eggs

Converting Number of Eggs to Time —From the above figures find the number of eggs necessary to bleach the area, then convert to days or weeks of production according to the rate of egg production during the period For instance, it requires about 35 eggs to bleach the beak completely If through this period the birds in the flock were laying at the rate of 66% on a hen-day basis, the actual time involved in bleaching the beak would be 53 days

Effect of Breed May Affect Rate of Bleaching —The lighter breeds, such as the Leghorns, will bleach their yellow color more rapidly than those birds from meat type lines Evidently, this is due to the thinner skin of the egg type strains

Return of Pigment When Laying Stops —Once the bird stops laying, the xanthophyll from the feed supply begins to find its way to the tissues that have become bleached The pigment returns in the same order as that in which it left, but it returns about twice as fast as it left the body

Minor Changes Resulting from Egg Production

There are some other changes in the bird during the course of egg production

(1) Vent becomes large and moist
(2) The pubic bones become thinner
(3) Space between the pubic bones increases
(4) Distance between the pubic bones and end of keel bone increases
(5) Skin on the skull becomes much thinner

Note Although the above five points are evident during egg production, they are only a measure of whether the bird is or is not laying They cannot be used to determine the number of eggs a bird has laid, or will lay

Formation of the Egg

The actual avian egg as the embryologist knows it consists of a minute reproductive cell quite comparable to that found in mammals. But in the case of chickens, this cell is surrounded by yolk, albumen, shell membranes, and shell. The ovary is responsible for the formation of the yolk; the albumen, shell membranes, and shell originate in the oviduct.

The Ovary

At the time of early embryonic development two ovaries exist, but normally the right one atrophies, leaving only the left as functional. In rare instances, both may survive.

In the mature fowl the left ovary may be seen as a mass of small follicles containing ova. Evidently thousands are present, many times the number that will eventually mature with full-size yolks necessary for egg production.

Formation of the Yolk

The yolk is not the true reproductive cell, but a source of food material from which the minute cell and its resultant embryo partially sustain their growth. Deposits of yolk material are very slow at first and light in color. Eventually some of the ova will reach a diameter of 6 mm, at which time a few will begin to grow at an increased rate, their diameter increasing about 4 mm per day. During the short period of 7 to 9 days prior to ovulation, 95 to 99% of the yolk material is laid down.

The coloring material in egg yolk is xanthophyll, a carotenoid pigment, derived from the food the chicken eats. The pigment is transferred from the food to the blood stream, then quickly to the yolk. Consequently more is deposited during the hours the hen is eating than when she is resting (at night). This gives rise to deposition of light and dark yellow layers of yolk material depending on the dietary pigment available. Yolk formation is rather constant and the total thickness of both the light and dark deposits for a day is about 1.5 to 2 mm.

Location of germinal disc: The yolk material is laid down adjacent to the germinal disc which continues to remain on the surface of the globular yolk mass. Once the egg is laid, the yolk rotates so the germinal disc is uppermost.

The ovarian follicle is attached to the ovary by a slender stalk. It is through this that blood flows to carry the yolk materials. The follicle is highly vascular, except for an area of small width which circumvents the sac, and is known as the *stigma.*

What influences growth rate of ovum: Nothing practical has been discovered that will influence the growth of the ovum. If it were feasible, the size of the yolk and the entire egg could be increased. Growth rate of the yolk is not correlated with rate of lay, but seems rather to have a genetic association.

Ovulation

The ovary releases the ovum from the ovary through a process known as ovulation The follicle ruptures at the area of the stigma and in the case of the chicken, within 15 to 75 minutes after the previous egg is laid The ovulation process is evidently the result of hormone activity Time of day when the previous egg is laid does not seem to influence the time of ovulation The egg to-ovulation period varies according to the strain of chicken, season of the year, and many other factors Certain drugs are capable of speeding up the process, others inhibit ovulation for many days

Ovum drops into body cavity The rupture of the follicular sac releases the ovum, then in most instances it drops into the body cavity

Double ovulation When 2 ova are released simultaneously the completed egg may contain 2 yolks, in some instances only one is drawn into the infundibulum

THE OVIDUCT

The oviduct is a long tube through which the ovum passes and where the remaining portions of the egg are secreted The segments of the oviduct and their purpose may be summarized as follows

Infundibulum

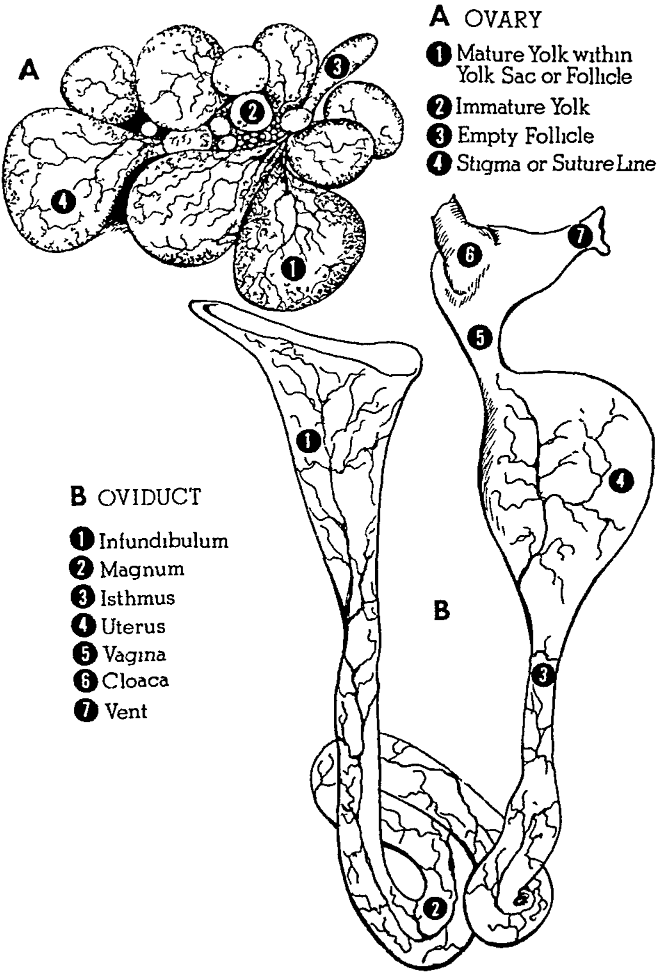
The funnel-shaped upper portion of the oviduct is the infundibulum When functional, its length is approximately 3 5 in (9 cm) Normally inactive except immediately after ovulation, its purpose is to search out and engulf the ovum so as to cause it to enter the oviduct An ovum remains in the infundibulum only a short period, normally about 15 minutes, then it is forced along by muscular contraction

Malfunction of the infundibulum To be completely functional the infundibulum should pick up all the ova dropped into the body cavity However, a good many are not drawn into the oviduct, but remain in the abdomen, where they either are absorbed or accumulate As many as 5% of the ova ovulated may remain in the body cavity with certain strains of chickens, resulting in a direct loss in the number of complete eggs produced

Internal layers On occasion the infundibulum loses its power to pick up a high proportion of the yolks, and they accumulate in the body cavity faster than they can be absorbed Such hens are known as "internal layers," although the term does not well define the condition

Magnum

The magnum is the albumen-secreting portion of the oviduct, and is about 13 in (33 cm) long in the average laying hen Here the firm albumen is secreted This form of egg white makes up approximately one-half of the final white Most of the protein of the egg is secreted in this portion The remaining white is secreted after the shell membranes are laid down, and consists mainly of water



From E Malinowsky, The Avian Embryo Ohio State Univ., Columbus, Ohio

FIG 3 1 ENLARGED DRAWINGS OF A OVARY, B OVIDUCT

Isthmus

Next, the developing egg is forced into the isthmus, a relatively short section approximately 4 in. (10 cm) in length. Here the inner and outer shell membranes are produced in such a manner as to represent the final shape of the egg. The contents at this time do not completely fill the shell membranes.

Soft shelled eggs. Many times the hen expels the partially completed egg after the shell membranes have been laid down. Such "eggs" are far from plump and resemble a sack only partially filled with water. Actually the term "soft-shelled" is a misnomer, no shell has yet been formed.

Uterus

The uterus is the shell gland, approximately 4 to 4.7 in. (10 to 12 cm) long in the laying hen. Here water and salts find their way through the shell membranes to complete formation of the egg albumen and to plump out the shell membranes. Next, the two layers of shell are deposited along with the coloring matter, porphyrin, which colors eggs in varying shades of brown. Here also the cuticle of the egg is deposited over the shell.

Vagina

About 4.7 in. (12 cm) in length, the vagina has no egg forming function.

Cloaca

The cloaca is the reservoir for the exits of the alimentary, reproductive and urinary tracts. It is here that the egg is held prior to laying. Of note is the fact that the developing egg traverses the oviduct with the small end ahead, but in the cloaca a horizontal rotation occurs just before laying, and normally the egg is expelled large end foremost.

DETAILS OF EGG FORMATION

The segments of the oviduct have been described, their functions have been the subject of much experimental work. Although all actions and interactions will not be discussed here, it is well that some of the details be covered.

The Albumen

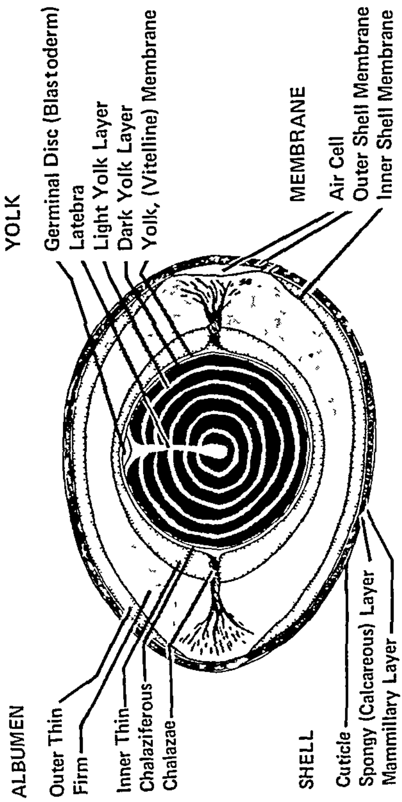
The albumen is composed of four layers. Their names and percentages are shown below as percentages of total albumen.

chalazae	2.7%	dense white	57.0%
inner liquid white	17.3%	outer thin white	23.0%

The Chalazae. Upon breaking an egg one notices two twisted cords extending from each side of the yolk through the thick albumen. These are produced when the yolk first enters the magnum, but cannot be observed until the egg is in the uterus.

The chalaziferous layer is laid down adjacent to the ovum, and represents the first secretion of the thick white. The layer extends itself into two cords, one approaching each end of the egg. Twisted in opposite directions, they tend to keep the yolk centralized.

Inner liquid white. After the chalaziferous white is deposited, a thin layer of liquid white is laid down. There is some evidence to show that the



From U S. *Dept of Agr Handbook 75, Egg Grading Manual,* 1968.

FIG. 3 2 THE PARTS OF THE NEWLY LAID EGG

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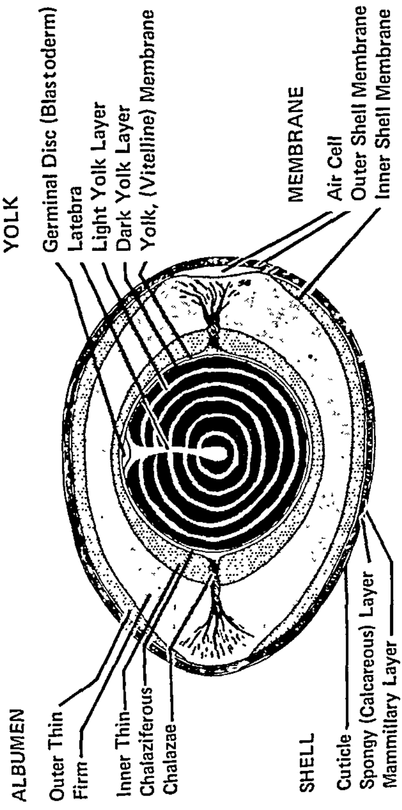


From: U.S. Dept. of Agr. Handbook 75, Egg Grading Manual, 1968.

FIG. 3.2. THE PARTS OF THE NEWLY LAID EGG

chalaziferous albumen and the inner liquid white may be the same, the twisting of the chalazae having squeezed out some of the albumen to form two portions

Dense white The dense white, or thick white, is deposited next It contains mucin, which tends to hold it together The amount of thick white generated in the magnum is large, but with the breakdown of mucin as the developing egg moves down the oviduct, the thick white is transformed to a thin albumen At the time the egg is laid, it has lost about one third of its original content of thick white, but what remains still comprises over half the albumen in the egg

Thick white decreases after egg is laid There is a continual transposition of thick white to thin white after the egg is laid, with the percentage of thick white decreasing and the percentage of thin white increasing The speed of this change may be modified by the temperature and conditions under which the egg is held

Outer thin white The last layer of albumen is deposited in the uterus It is a thin mucilaginous material that may easily be observed by breaking a shell egg into a flat dish The thick white tends to stand up near the yolk, the thin white runs to a shallow level at the outside

Egg deterioration After laying there is a constant change in the interior contents of the egg the thick albumen does not stand up as well, but decreases in volume, and the thin white becomes less viscous with an increase in amount

Cause of Bloodspots

If there is a hemorrhage of the blood vessels in the follicular sac at the time of ovulation small clots of blood will appear Some will adhere to the ovum as it passes through the oviduct, and the completed egg will contain these bloodspots Some blood clots from the oviduct may adhere to the yolk The incidence is related to many things, genetics, feed, age of hen, and others Brown shelled eggs have a higher percentage than white-shelled

Cause of Meatspots

Any tissue sluffed from the follicular sac or the oviduct probably will be included in a part of the developing egg as it passes through the oviduct These bits of tissue darken with age and are known as meatspots Many blood clots darken too, and are often called meatspots

The Shell Membranes

Next to be deposited is the inner shell membrane, a papery material composed of protein fibers This is followed by an outer shell membrane, about five times as thick as the inner The two are held closely together as one except at a point known as the *air cell* Here the two are separated, the point of separation usually being in the large end of the egg, but it may be "misplaced" and occur in the small end or on the sides in a small percentage of eggs

Air-cell size important At the time the egg is laid the diameter of the air cell is about 0 7 in (1 8 cm), but as the egg ages and the interior dehydrates, the air cell increases in diameter and depth The size of the air cell

in a shell egg is an excellent indicator of the age of the egg, but may be altered according to the conditions under which the egg is kept.

Shell membranes act as barrier: The shell membranes act as a barrier to penetration by outside organisms such as bacteria. They also prevent the contents of the egg from evaporating too rapidly. The membranes aid in protecting the egg contents.

The Shell

Next the shell is deposited around the outer shell membrane, as two layers, (1) inner shell and (2) outer shell. A mammillary layer on the outside of the outer shell membrane is composed of calcite crystals, a sponge-like material. This deposition is quickly followed by the addition of the outer shell, another layer of calcite crystals, chalky and about twice as thick as the inner shell. These crystals are almost perpendicular to the shell surface. Thus, the actual eggshell is composed almost entirely of calcite with small deposits of sodium, potassium, and magnesium.

Shell deposition slow: Compared with the formation of other parts of the egg, the egg remains in the uterus for as long as 16 hours before all the shell is deposited.

Source of calcium for the eggshell: There are but two sources of calcium for eggshell production, the feed and the bones. Normally, most of the calcium for eggshell formation should come directly from the feed, and the balance from certain bones.

Medullary bone: In the commercial chicken, producing a number of eggs far beyond the number laid under natural conditions, the demand for calcium for eggshell is tremendous. With the onset of egg production the marrow area of many of the long bones develops secondary bone material known as medullary bone. This becomes the source of about one-third the calcium of the eggshell, the balance coming directly from the feed. The medullary bone is the reservoir of calcium to be used when the blood-calcium level is not adequate. Although the process is not clearly understood, it is closely associated with certain hormones.

Poor shell quality: Normally, laying hens tend to produce successive eggs that are similar in shape, color, and shell texture, except for the fact that there is a gradual decline in shell quality as the egg production period becomes longer. Several other factors cause deterioration of eggshell quality:

(1) quality reduced the longer the bird continues to lay;
(2) increased environmental heat;
(3) stress of birds in the breeder flock;
(4) certain poultry diseases (bronchitis, Newcastle disease, etc.);
(5) nutritional deficiencies;
(6) certain drugs.

How much calcium is needed for eggshell production? The demand of the laying hen for calcium is extremely high. A 4-lb hen producing 250 two-ounce (56.7-gm) eggs per year requires about 3.11 lb (1.41 kg) of calcium carbonate, or 1.25 lb (0.57 kg) of calcium. As this is about 25 times the amount of calcium in the bird's skeleton, it is evident that the dietary

need for calcium is exceptionally high. Most laying rations should contain from 2.5 to 3.75% calcium to meet the demand.

Pores in the eggshell. Both the inner and outer shell layers contain thousands of small openings called pores. Through these oxygen is taken into the egg, and carbon dioxide and moisture are expelled. In the freshly laid egg most of these pores are closed, but as the egg ages the number of open pores is visibly increased. There may be as many as 8,000.

Color of eggs. The color of the eggshell is continuously consistent for each bird, the density being a derivative of the genetic makeup of the individual bird. Some strains lay eggs with very dark brown shells, while others vary all the way to pure white.

The Cuticle

Laid down on the outside of the shell is the last of the concentric layers in egg formation. It is known as the cuticle and is composed primarily of organic material. Containing a high percentage of water, it acts as a lubricant during the laying process. When the egg is first laid the cuticle material is moist, but it soon dries, blocking off many of the pores of the eggshell to prevent too rapid exchange of air and moisture.

SHAPE AND SIZE OF THE EGG

Shape

The shape of the egg generally is due to inherited genetic factors. Each hen lays successive eggs of the same shape, i.e., long, pointed, round, thick, etc.

Imperfections of egg shape. Many hens continually lay eggs with shape imperfections. These come under several categories: ridges, pointed at tip, etc. Similar imperfections will be found on each egg the hen lays. Some are of genetic origin, others are probably due to abnormalities of the oviduct.

Other shell imperfections. There are many eggs produced with shells other than normal. Some of these are:

chalky shells	porous shells
thin shells	light-colored shells

Size

Eggs from a flock of chickens vary in size (or weight) in many ways. The exact cause of some of the variations is not known, but much has been established regarding others. Some of these variations are as follows:

(1) Some hens lay eggs that are larger or smaller than those laid by other hens. Obviously, this difference is due mainly to genetic factors.

Size of egg yolk may determine egg size. Except in unusual cases, the size of the yolk is largely instrumental in determining final egg size. The larger the yolk, the larger the egg. But the ability of the oviduct to secrete albumen also may alter the size of the completed egg.

(2) The first eggs a hen lays are smaller than those laid later. Egg size gradually increases as the hen continues to lay, but the increments of increase are not uniform.

(3) The time of laying eggs within a clutch affects egg size The first egg of the clutch is the heaviest, each succeeding egg being proportionately smaller In such instances the yolk size is reduced, but the decrease in size of future eggs is due also to a decrease in the amount of albumen produced

(4) Some feed components, such as protein, will affect egg size In most instances egg size may be increased by increasing the protein content of the feed

(5) Hot weather affects the flock, causing a decrease in the egg size

TIME INTERVALS INVOLVED IN EGG FORMATION

Although varying with individual hens, the time spent in each section of the oviduct by the developing egg was established by Warren and Scott, after whom Table 3 1 is patterned

TABLE 3 1

TIME INTERVALS INVOLVED IN EGG PRODUCTION

Section of the Oviduct	Approximate Time in Hours
infundibulum	0 25
magnum	3 00
isthmus	1 25
uterus	16 00
vagina	4 75

Eggs Laid in Clutches

It is a well known fact that hens tend to lay eggs in clutches That is, eggs are produced on several consecutive days before any days are missed High egg producers have longer clutches than poor ones It is further known that during the period of the clutch all hens do not lay eggs at equal hourly intervals, the interval may vary between 22 and 26 hours The longer periods are associated with variations in the rate of passage of the developing egg through the oviduct Egg pro

TABLE 3 2

LENGTH OF EGG FORMATION PERIOD AND TIME SPENT IN PARTS OF OVIDUCT

	Hens with Hours of Interval Lengths of					
Item	25	26	27	28	29	30
Time from laying of one egg to entrance of isthmus by next egg (hr)	4 3	4 6	4 2	4 7	5 2	5 3
Time in uterus (hr)	18 0	18 4	19 9	19 8	20 8	21 6
Time from first indication of shell to laying the egg (hr)	13 8	14 7	15 6	16 4	17 0	17.9

Source Warren and Scott 1935

TABLE 3 3

MAKEUP OF THE NEWLY LAID EGG

Component	Approximate % of Total Weight: Egg Without Shell	Approximate % of Total Weight: Egg with Shell
Protein	11 3	12
Fat	11 2	10
Carbohydrate	5	1
Mineral	1 9	11
Other	1 1	—
Water	74 0	66

Source G M Briggs, PENB 22nd Ann Meeting

ducing birds, with small clutches, and long intervals between the clutches, have delays between the time of laying and the next ovulation. Thus, poor-producing hens are at least the partial result of a long period to complete the formation of the egg and a longer delay in the next ovulation.

Table 3 2, compiled from Warren and Scott, is an excellent exemplification of this theory.

Chemical Composition of the Fresh Egg

The chemical composition of the fresh egg is shown in Table 3.3.

Development of the Chick Embryo

Processes involved with modern artificial incubation of chicken eggs should be prefaced with a brief description of the development of the chick embryo. Unlike that of the mammal, the avian embryo develops from food material stored in the egg rather than from nutrients derived from the blood supply of the mother. Furthermore, most of chick embryo growth takes place outside the body of the mother, and development is more rapid than in the case of mammalian embryos.

FERTILIZATION

Natural Fertilization

Normally fertilization is a natural process, but artificial insemination also is practical. During the course of a normal mating between a male and female chicken the male ejaculates millions of sperm cells. These immediately find their way to the upper part of the oviduct of the hen, the infundibulum (funnel). If no egg is in the oviduct, the process takes but 30 minutes. Within 15 minutes after ovulation, a few sperm cells find their way to the area of the pronucleus on the surface of the egg yolk. Several of these cells may enter, but only one actually unites with the female egg cell to form a new individual, the *zygote*. After a single mating by the male, fertile shell eggs may be produced within 20 hours, but normally maximum fertility from a flock of hens will not be attained until about the third day.

Fertility after removal of males from flock: If the males are removed from the flock of hens, some fertile eggs will be produced for as long as four weeks; but the percentage of infertile eggs increases each day after removal of the males, the increase being quite rapid after the fourth or fifth day.

Viability of newly produced sperm: New sperm cells are more viable than old ones. Because of their increased viability they are more likely to unite with the female egg cell. Thus, if the males are removed from a flock, and new ones substituted on the same day, practically all the fertilization after three days will be from the new males.

Fertilization with reference to time of mating: With natural mating the time of day that copulation occurs does not seem to affect the degree of fertilization of the egg cells. This is different in the case of artificial insemination, when the presence of an egg with a hard shell in the uterus acts as a deterrent to sperm mobility.

Artificial Insemination

It is possible to obtain semen artificially from the male chicken which is used to inseminate females. The process must be repeated every four or five days if maximum fertility is to be accomplished, for fertility drops rapidly after the fifth day.

Insemination should be completed in late afternoon: The process should be completed at a time *other* than 4 hours before, or 1 hour after, laying. Morning inseminations are likely to produce lower fertility as most eggs are laid during this period.

Semen cannot normally be stored Unlike mammalian semen, avian semen is difficult to store It will not stand quick freezing, but under certain conditions, it may have some viability when thawed after being frozen with approved techniques Its fertilizing properties, however, will be greatly impaired

EMBRYONIC DEVELOPMENT BEFORE LAYING OF EGG

After formation of the zygote through the union of the sperm and egg cells, the development of embryonic structures begins Within five hours after ovulation the first cellular division takes place at a time when the developing egg is in the isthmus Shortly thereafter, another division takes place, then another, and when the egg leaves the isthmus the developing organism is composed of 16 cells After 4 hours in the uterus some 256 cells are present

Since the body temperature of the hen is 105° to 107°F (40 6°–41 7°C) cellular division continues at a rapid rate prior to the time the egg is laid Several thousand cells will have been produced and the developing blastodisc represents a complex unit Cellular division will continue as long as the egg remains above about 75°F (23 9°C) When eggs are held at temperatures lower than this, the cells cease to multiply From a practical standpoint, hatching eggs should be kept at a temperature of 65°F (18 3°C) from the time they are laid until they are ready for artificial incubation in order to give assurance that cellular growth will be completely eliminated

DEVELOPMENT DURING INCUBATION

The Extraembryonic Membranes

Because the embryo has no anatomical connection with the mother's body, nature has endowed it with certain membranes necessary to utilize all of the food elements contained in the egg These "extra" membranes are as follows

Yolk sac Enveloping the yolk, this membrane secretes an enzyme that changes the yolk contents into a soluble form so that the food material may be absorbed and carried to the developing embryo The yolk sac is drawn into the body cavity just prior to hatching to serve as a source of food material

Amnion The amniotic sac is nature's provision to prevent injury during embryonic development It is filled with a transparent fluid in which the embryo floats

Allantois This membrane serves as a circulatory system, and when fully developed completely surrounds the embryo It has the following functions

- *Respiratory* It oxygenates the blood of the embryo and removes the carbon dioxide
- *Excretory* It removes the excretions of the embryonic kidney and deposits them in the allantoic cavity
- *Digestive* It aids in the digestion of albumen and in the absorption of calcium from the eggshell

The allantois is initiated on the third day and is fully developed by the twelfth day

Chorion. This membrane fuses the inner shell membrane with the allantois, and helps the latter in completing its metabolic functions.

The Air Cell

During the incubation process moisture is lost from the egg contents through the shell. This increases the size of the air cell, and after 19 days of incubation it may occupy one-third of the egg.

Time Factors in Development

The development of the chick embryo is a complicated process, and has been studied and reviewed in detail by embryologists. Only the main changes will be discussed below:

First Day

Several embryonic processes are in evidence during the first 24 hours of incubation.

16 hours: First sign of resemblance to a chick embryo through the development of the somites, block-like structures that develop on both sides of the spinal cord. From these bone and muscle develop.

18 hours: Appearance of the alimentary tract.

20 hours: Appearance of the vertebral column.

21 hours: Origin of the nervous system.

22 hours: Head begins to form.

24 hours: Eyes originate.

Second Day

25 hours: Heart and blood vessels begin to develop.

35 hours: Beginning of the formation of the ear.

42 hours: Heart begins to beat. Blood circulation begins with the joining of the blood vessels of the embryo and the yolk sac. This is a very critical period in the life of the embryo and lasts for over two days.

Third Day

60 hours: The nose is initiated.

62 hours: The legs begin their development.

64 hours: Beginning of the formation of the wings. The embryo begins to rotate so that it lies on its left side. The circulatory system is rapidly increasing during the third day.

Fourth Day

With the beginning of the development of the tongue, all body organs are present. The vascular system is clearly evident to the naked eye.

Fifth Day

The reproductive organs differentiate, and sex is developed. The heart begins to take a definite shape and the vascular area of the yolk sac covers two-thirds of the yolk. The face and nasal portions of the embryo begin to take a definite shape.

Sixth Day

The beak and the egg tooth begin to take a normal form Some voluntary movement of the embryo may be noticed

Seventh Day

The body begins rapid development, more so than the head Body organs are visible

Eighth Day

Feather germs, the origin of the feather tracts, appear

Tenth Day

The beak begins to harden, toes start to appear, as well as scales on the legs

Eleventh Day

The walls of the abdomen appear, and the intestines may be seen in the yolk sac

Thirteenth Day

Chick down is present, the skeleton is beginning to calcify, and most organs are differentiated with only final growth necessary

Fourteenth Day

The embryo rotates to position itself parallel to the long axis of the egg with the head normally toward the large end

Seventeenth Day

The head turns so that normally the beak is under the right wing and toward the lower part of the enlarged air cell

Nineteenth Day

The yolk sac begins to enter the body cavity and the chick finds a position necessary for pipping the shell This yolk material is used as food supply during the first few days of the chick's life

Twentieth Day

The yolk sac has completed its entrance into the body cavity The embryo occupies all the area within the shell except for the air cell The umbilicus is beginning to close Next the beak of the chick penetrates the inner shell membrane and enters the air cell Slowly the chick inhales some air, and pulmonary respiration begins Next it pips the shell and gains entrance to outside air At this time the lungs become fully functional, and the chick is under a critical stress, the second in its life

Twenty first Day

After first pipping the shell, the hatching process is continued, with the chick, aided by the egg tooth, cutting a circular line around the eggshell in a counter clockwise direction Normally, if the embryo has positioned itself correctly prior to hatching, this is near the large end of the egg Fifteen to 20 hours may be consumed from the time the shell is first broken until the chick is able to liberate itself

EMBRYONIC METABOLISM

The developing embryonic chick requires protein, carbohydrates, fats, minerals, vitamins, water and oxygen to complete its normal development. All but the last are found within the eggshell

Energy

Energy for the chick comes from protein, carbohydrates and fat, but the source varies with the age of the embryo Carbohydrate furnishes the supply during the first four days, protein being utilized thereafter, as evidenced by the formation of urea, a by-product of protein metabolism Fat from the egg yolk is the probable source of energy during the latter part of the incubation period, but it cannot be surmised that the processes are so well established that one or another does not carry over into a different period of time

Minerals

Calcium is the most important mineral involved in embryonic metabolism. It is transferred from the shell to the embryo. In fact the calcium content of the egg contents and embryo rises markedly beginning with the twelfth day, and the increase in both is parallel, although the amount in the embryo is always greater than that of the egg contents. The fact that even the amount of calcium in the shell membranes increases during incubation offers further proof of the transfer of calcium from the shell to the shell membranes Additional proof is noted in the fact that infertile eggs, incubated with fertile eggs, show no transfer of calcium from the shell to the interior contents or shell membranes.

Chick Hatcheries

Chick hatcheries are modern buildings which provide a place to hold hatching eggs prior to setting, a room for grading and traying the eggs, rooms for incubation and hatching, and a chick storage and grading room Other rooms may be necessary to accomplish the necessary chores involved with hatchery management.

SIZE AND LOCATION

Determining the Size of the Hatchery

The size of the hatchery is computed in various ways Egg capacity of the incubators, number of eggs that can be set each week or setting, and number of chicks that can be hatched each week or setting Table 5 1 shows the relationships between these measurements when eggs are set twice weekly

TABLE 5 1

METHODS USED FOR INCUBATOR CAPACITY[1]

Egg Capacity of Incubators (*including both Setters and Hatchers*)	Number of Eggs that can be Set		No of Chicks that can be Hatched at 80% Hatchability	
	Per Setting	Per Week	Each Hatch	Each Week
100,000	16 666	33,333	13,333	26,667
200,000	33,333	66 667	26,337	53,333
400,000	66,667	133,333	53,333	106,667
600,000	100,000	200,000	80,000	160,000
800,000	133,333	266,667	106,667	213,333
1,000,000	166,667	333,333	133,333	266,667

[1] Chicks hatched twice weekly

Location of the Hatchery

Because of the importance of isolation in modern MG and MS disease-control programs, proper location of the hatchery is important It should not be near buildings in which chickens or other fowl are located Also, it should be situated at least 500 ft (152 m) from poultry houses, but even this distance is not enough to insure that there will not occasionally be horizontal transmission of disease-producing organisms from the chicken houses to the hatchery The hatchery should be a separate unit with its own entrance and exit, unassociated with those of the poultry farm

PERSONNEL FLOW THROUGH HATCHERY

One of the requirements for a MG free and MS free hatchery is that all persons entering the premises must shower and change into clean clothing in an adjoining room They may leave only through this same room where they change back into

street clothing. Thus, this shower room becomes an integral part of hatchery planning. It is the only entrance and exit, and the hatchery becomes an isolated unit so far as human beings are concerned. All other doors must be kept locked at all times to make certain that the human element in the transfer of infectious diseases is eliminated.

The shower room must be carefully constructed so that those entering the hatchery may gain entrance only through the water from the shower; they must not be able to walk around it. There also must be a room or area for disrobing and another for dressing in clean work clothes. Some method of heating the rooms during cold weather should be provided. An individual locker for each employee is advantageous.

EGG-CHICK FLOW THROUGH HATCHERY

Hatcheries should be constructed so that the hatching eggs may be taken in at one end and the chicks removed at the other. In other words, eggs and chicks should flow through the hatchery from one room to the one next needed in the hatching process. There should be no backtracking. Such a flow affords better isolation of the rooms and there is less human traffic throughout the building. Care in designing the floor arrangement of a hatchery will result in fewer steps. A diagrammatic flow system is shown in Fig 5 1.

Although Fig. 5.1 shows the normal route of eggs through a hatchery, such an elongated design is practical only in the case of small hatcheries. In most cases, rooms must be arranged to give better use of the building, afford a shorter route for the eggs, and reduce employee movement through the rooms.

Many commercial incubators are constructed so that they lend themselves to improved design; hatchery floor space is reduced to a minimum, and egg movement from room to room is more economical. Most incubator manufacturers have engineering departments that design hatcheries to fit almost every need.

Getting Hatching Eggs into the Hatchery

Employees delivering hatching eggs to the hatchery must not enter the hatchery in the course of their duties Eggs should be delivered to the door of the fumigation cabinet. A hatchery employee takes the eggs from the unloading dock into the fumigation room.

Removing Chicks from the Hatchery

Similarly, employees responsible for loading chicks into chick delivery vans must not enter the hatchery building Hatchery employees should deliver chick boxes to the truck delivery door where they are taken by the truck driver and loaded into the truck. Under no condition should the hatchery employee walk through the delivery door, or the truck driver enter the hatchery through the chick delivery exit.

HATCHERY CONSTRUCTION

Hatchery buildings are no longer assembled in a hit-or-miss fashion. They are intricately designed, properly constructed, and ventilated. The cost will vary between \$100 and \$140 per 1,000-egg incubator capacity. An architect should be

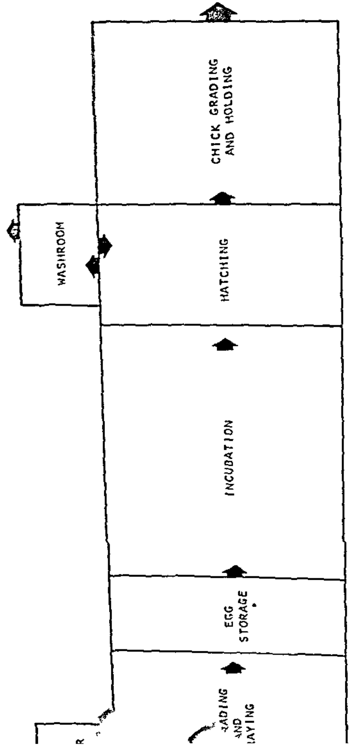


FIG 5 1 EGG CHICK FLOW THROUGH HATCHERY

employed to draw the details and write the specifications. Only brief, general points will be considered here.

Truss Design

Unless the hatchery building is extremely wide, the truss design should be used for supporting the roof. As the hatchery must be ceiled, almost any type of roof design may be used—flat, gable, monitor or shed. Posts should be avoided if possible. If it is necessary to use posts, a floor design should be drawn, showing the location of all hatchery equipment. Posts may be used in construction when they will not interfere with the equipment or hatchery chores.

Width of Hatchery

The width of the incubator and hatcher rooms will be determined by the type of incubator used. Find the width of the incubators, then allow space for the working aisles, behind the machines (if necessary), and the walls. The total width of the room may then be determined. Other rooms in the hatchery must be built "around" these two rooms to provide proper egg flow, and so that the entire edifice may present a pleasing design and appearance.

Ceiling Height

Most commercial hatcheries are built with forced-draft ventilating systems. Thus, there is no need for high ceilings. The height recommendation is 10 ft (3.1 m).

Walls

Fireproof material should be used in constructing as much of the hatchery building as possible. As the interior of the hatchery building is continually being washed and disinfected, the inside of the walls should be covered with a glazed, hard, nonabsorbent finish. This also prevents the growth of molds common to walls that are porous and absorbent.

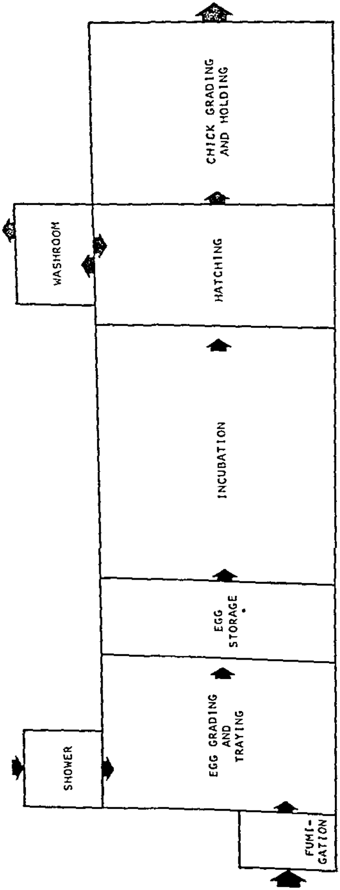
Concrete blocks lend themselves very well to wall construction. They may be painted with a material that seals the pores of the blocks and leaves a hard, glazed surface. Inside walls between rooms should not be built of wood, as the water remaining after each washing eventually rots it. If wood has to be used, it should be pretreated and waterproofed.

Ceiling Material

Most hatchery rooms, particularly those involved with incubation and hatching, have a high humidity, and during cold weather condensation of moisture on the ceiling is common. This makes it impractical to construct the ceilings of any material that will deteriorate in the presence of water. Plaster should not be used. The best materials are waterproof pressed woods, or metals. Insulation over the ceiling will eliminate a good share of moisture condensation. Adequate ventilation in the rooms to lower humidity will also help, as will negative pressure.

Doors

Most common doors are 7 ft (2.1 m) in height, but these are not adequate for a hatchery. Because chick box racks and other high equipment must be moved through the hatchery doors, openings should be 8 ft (2.4 m) high and at least 4 ft (1.2 m) wide, and doors double-swinging. Those into the washroom and those at



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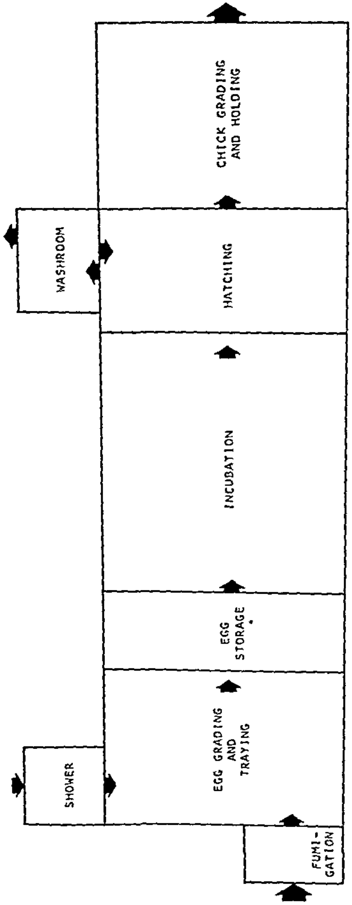

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the chick box exit should be much wider All hatchery doors through which equipment is moved should be equipped with metal bumper guards

Floor Construction

All floors must be concrete, preferably with imbedded steel to prevent cracking The concrete must be given a glazed finish There must be no high or low spots, for floors are to be washed almost daily All water must drain away, none must be left standing

Slope of the floor Floor drains should be numerous and the slope of the floor to the drain should never be greater than 1 in (2 54 cm) in 10 ft (3 1 m) Otherwise, hatchery equipment will not roll over the floor easily

Floor drains Tremendous quantities of water are used in the hatchery No smaller than 6 in trap type floor drains should be used Be sure these have a flat top so hatchery equipment can be rolled over them easily

Another method is to construct a gutter about 6 in (15 cm) wide and 6 in (15 cm) deep in the concrete floor in such a way that water will run to one end of the gutter and into the sewer system Cover the gutter with a steel plate in which holes have been drilled

Special floor trap in washroom In the washroom a special floor drain and trap are needed because of the large volume of broken eggshells and other debris washed from the hatching trays

This trap should be about 32 in (81 3 cm) long, 16 in (40 6 cm) wide, and 16 in (40 6 cm) deep A removable divider plate should be built in the center so that the top comes 4 in (10 2 cm) below floor level The entire trap is then covered with a steel plate in which ½ in (1 27-cm) holes have been bored in one half, leaving the other half unaltered A 4 in (10 2-cm) pipe should be extended through the concrete when the trap is built The top of this pipe should be about 2 in (5 1 cm) below the top of the trap Attach an elbow to the pipe on the inside of the trap so that the open end is down Cover the trap with the steel plate so that the holes are in the end opposite the drain pipe

Debris finds its way through the holes of the plate and settles to the bottom of the first compartment, the water running over the plate dividing the two sections Additional settling of any remaining debris takes place in the second section, and water finds its way out through the elbow to the drain The steel cover plate may be removed to scoop out the settled debris

Sewers

Sewers should be larger than used on most industrial buildings This requirement is necessary because

(1) A very large amount of water is involved
(2) Broken eggshells settle out in the sewer lines if the water does not flow fast enough

Caution Give all sewer lines additional slope This aids in removal of broken eggshells and other debris

ectric Lines

Electric lines may be laid below the concrete floor in waterproof conduits, or er the ceiling. If many changes in the location of the incubators and other elec-cal equipment are contemplated, the electric lines should be over the ceiling.

ater Lines

These are best placed below the concrete floor. Water from those laid over the eiling is warmer and, as many incubators use water to cool the interior, cool water better than warm. Most incubator manufacturers have recommendations for the roper installation of water lines.

> *Remember*: Large amounts of water will be used in the hatchery for washing hatching trays and cleaning, as well as in the incubators. Be sure the incoming water lines are adequate in size and that there is ample water pressure.

Docks

Unloading eggs from trucks and loading chicks into trucks will be implemented if a dock constructed at truck height is used. The top of the dock should be level with the floor of the hatchery, constructed of concrete, with a drain in the center.

> *Caution: Water that has been used to wash docks should not be allowed to run back into the hatchery or on the ground by the dock. Construct drains to carry the water away.*

Enlarging the Hatchery

The floor plan of most hatcheries should have provisions for expansion. Generally this means that almost every room will have to be enlarged. The original plan should be one that may undergo expansion when necessary. Do not get "boxed in" with permanent walls or rooms that cannot be expanded.

HATCHERY ROOMS

Hatchery rooms must be of adequate size. It is better to have them too large than too small. Usually, hatcheries of medium size will hatch chicks twice a week, but large, commercial operations may hatch oftener, as many as five or six times per week, in order to equalize the daily work load. Therefore, hatching schedules will affect the size of some of the rooms in the hatchery.

Recommended Room Sizes

Table 5.2 shows general recommendations for floor space of various hatchery rooms where two hatches per week are taken off.

The fumigation room should be as small as possible in order to reduce the amount of fumigant used for each fumigation. Its size should be that volume necessary to hold but one pickup of eggs.

The size of the incubator and hatcher rooms will depend on the make of equipment used. Some do not require separate rooms. The manufacturer will be able to supply these dimensions and other necessary statistics.

Egg-Holding Room

The egg-holding (egg-cooler) room is important if hatching-egg quality is to be maintained. It should be 7 ft (2.13 m) high, well-ventilated with complete air

TABLE 5.2

FLOOR SPACE FOR HATCHERY ROOMS
(2 hatches per week)

Room Type	Per 1000 Eggs Incubator Hatcher		Per Case of Eggs Set per Setting (360 Eggs/Case)		Per 1000 Straight run Chicks Hatched per Hatch	
	Sq Ft	Sq M	Sq Ft	Sq M	Sq Ft	Sq M
Egg receiving room	2 00	0 19	4 32	0 40	15 00	1 39
Egg storage room[1]	0 33	0 03	0 71	0 06	2 47	0 23
Chick holding room	4 00	0 37	8 64	0 80	30 00	2 79
Wash room	0 80	0 07	1 73	0 16	6 00	0 55
Storage room	0 70	0 07	1 51	0 14	5 25	0 49

[1] When cases are stacked four high

movement, cooled, and humidified It should be constructed with the walls and ceiling having the following "R" values (see Chapter 11) to give adequate insula tion

Walls "R" value of 12

Ceiling "R" value of 16

Refrigeration The room must be refrigerated to maintain a room tempera ture of 65°F (18 3°C) A forced air type of refrigeration unit must be used in order to maintain a uniform temperature throughout the room

Measuring unit size Capacity, or size of the refrigeration unit, is measured in Btu per hour The Btu rating represents the rate of heat removal Sometimes the units are rated in tons A ton of refrigeration is equiva lent to 12,000 Btu per hour At other times the unit is rated according to the size of the compressor—1 hp, 2 hp, etc

Calculating size of refrigeration unit Room insulation, outside tempera ture, and other factors will determine the size of the unit needed to cool the room adequately The following calculation will provide an estimate of the size required

Item	Btu heat removed per hour
Floor area in sq ft × 3 00	______
Wall plus ceiling area in sq ft × 4 00	______
Number of dozens of eggs cooled per day × 5 5	______
Miscellaneous 35 Btu for each 10 sq ft of floor space	______
Total Btu Required	______

Refrigeration units vary in size and cooling capacity Specifications for some are given in Table 5 3

HATCHERY VENTILATION

Forced air should be used to ventilate the hatchery Uniformity of temperature and humidity throughout the hatchery is of the utmost importance Forced air seems the only practical solution

TABLE 5 3

SIZE AND RATINGS OF REFRIGERATION UNITS

Dozen of Eggs per Day	Room Size[1] Ft	Room Size[1] M	Refrigeration Unit Hp	Refrigeration Unit Tons	Refrigeration Unit Btu
800	11 × 12 × 7	3 3 × 3 7 × 2 1	1/2	1/2	6,000
1200	12 × 21 × 7	3 7 × 6 4 × 2 1	3/4	3/4	9,000
1600	16 × 21 × 7	4 9 × 6 4 × 2 1	1	1	12,000
3100	21 × 28 × 7	6 4 × 8 5 × 2 1	2	2	24,000

[1] Necessary to set twice weekly

Air should not be circulated from one room to another Each room must be ventilated as a separate unit, air being exhausted to the outside rather than into an adjoining room

Incoming air should be filtered, preheated in the winter, and cooled in the summer A duct system for circulating the air uniformly in each room is best Through these ducts warm air may be circulated in the winter, cool air in the summer

More air must be moved through the hatchery rooms during the hot months than during the cool Therefore, rheostats should be installed on all ventilating fans to provide increased or decreased airflow

Air Movement Through Hatchery Rooms

Table 5 4 shows the amount of air that should flow through the hatchery rooms according to outside temperatures

TABLE 5 4

AIRFLOW PER MINUTE THROUGH HATCHERY ROOMS

Outside Temperature °F	Outside Temperature °C	Per 1000 Cu Ft Per 28 3 Cu M — Egg handling Room Min[1]	Egg handling Room Optim[2]	Per 1000 Eggs — Incubating Room Min	Incubating Room Optim	Per 1000 Eggs — Hatching Room Min	Hatching Room Optim	Per 1000 Chicks — Chick holding Room Min	Chick holding Room Optim
30	−1 1	111[3] *3 1*[4]	125 *3 5*	20 *6*	27 *8*	53 *1 5*	71 *2 0*	98 *2 8*	133 *3 8*
60	15 6	167[3] *4 7*[4]	187 *5 3*	30 *9*	40 *1 1*	80 *2 3*	106 *3 0*	146 *4 1*	200 *5 7*
90	32 2	190[3] *5 4*[4]	250 *7 1*	45 *1 3*	60 *1 7*	120 *3 4*	160 *4 5*	225 *6 4*	300 *8 5*
Optimum air change in room at 98° F (36 7° C) outside		Once every 4 minutes		Once every 3 minutes		Once every 2 minutes		Once every 1 minute	

(1) Minimum.
(2) Optimum.
(3) Cubic feet
(4) Cubic meters.

Negative Pressure Ventilating System

Because most hatchery ventilating systems call for forcing air into the rooms, rather than exhausting it, a slight pressure is built up Thus there must be some type of exhaust to make the system work efficiently Exhaust fans should move slightly more air than the intake fans, creating a negative pressure in the rooms When this recommendation is reversed there is likely to be unequal distribution of air in the hatchery rooms and more condensation of moisture

Air Delivered by Ducts

Air from the hatcher and chick holding rooms should be exhausted through a water bath to prevent the chick down from these two rooms from being blown into the open air, then perhaps being redrawn into the intake ventilating system and recirculated to all hatchery rooms The water tank may be located in the attic to prevent freezing in the winter A disinfectant should be added to the bath water to help prevent the dissemination of any disease producing organisms

Exhaust Air Through Water Bath

With the negative pressure system of ventilation the air must be moved by ducts to provide uniform distribution in the room These also reduce the speed at which the air must travel Although there may be one main duct for taking air from an inlet to the various hatchery rooms and another main one for exhausting it, there must not be a transfer of air from room to room Such a procedure, although con serving heat in the winter, only aids in the dissemination of disease producing organisms

Capacity of Electric Fans

The fan capacities shown in Table 5 5 are approximate Width, angle, and shape of the fan blade affect the amount of air delivered Figures are for free delivery of air Normally fans move about 90 to 95% of the following cubic feet per minute (cfm) or cubic meters per minute (cmm)

Caution Many fans do not move their designated or rated amount of air Loose belts, dirty blades, improper pitch of the blades and high static pressure in the building are contributing causes of inadequacies Check the speed of all fans, and look for loose belts

TABLE 5.5

CAPACITIES OF ELECTRIC EXHAUST FANS

Motor		Fan Blades			Air Capacity @ O Static Pressure	
			Diameter			
Hp	Rpm	No	In	Cm	Cfm	Cmm
1/8	1725	4	12	30 4	1650	46 7
1/4	1725	4	18	45 7	2900	82 1
1/4	1140	4	18	45 7	1800	50 9
1/3	1140	5	18	45 7	3600	101 9
1/2	1140	5	24	60 1	5300	150 0
1/3	630	4	24	60 1	6200	175 5
1/3	473	4	30	76 2	6300	178 3
1/2	412	4	36	91 4	12000	339 6

COOLING THE HATCHERY

During periods of hot weather it becomes necessary to cool the hatchery rooms. Certain rooms require more cooling than others. For instance, the chick room is usually the first to show temperature increases because of the buildup of heat from the chicks. Next is the hatching room. Incubators operate better if the room in which they are located has a temperature of 70°-72°F (21.1°-22.2°C). The most economical method of reducing the temperature in hatcheries is with evaporative coolers.

Principle of Evaporative Cooling

The theory of evaporative cooling is based on the fact that air at any given temperature has but one point of complete saturation. That is known as 100% relative humidity. If the temperature of the air rises, it is no longer saturated, as warm air holds more moisture than cool air. Cooling of air when it is at 100% relative humidity results in moisture condensation and precipitation. However, when the air is not saturated (less than 100% relative humidity) evaporation of moisture occurs. The lower the relative humidity, the greater the evaporation. The evaporation produces a cooling effect. The temperature to which cooling is reduced may be determined by taking a wet-bulb thermometer reading.

Example: If the dry-bulb reading is 90°F (32.2°C) and the wet-bulb reading is 75°F (23.9°C), evaporation will cool the air to 75°F (23.9°C). Under ordinary use, however, one cannot expect the temperature reduction to reach the wet-bulb reading because of other factors involved. Normally, the actual reduction will be about 80% of the calculated reduction.

The Evaporator-cooler

Air is seldom saturated with water vapor, and when it is forced through a wet pad it absorbs moisture by evaporation. The evaporation of moisture has a cooling effect; the lower the relative humibidy of the air the greater the evaporation, and the greater the cooling.

A practical application of the above phenomenon is made in using commercial evaporator-coolers. These come in varying sizes from 2 ft (0.6 m) to 10 ft (3 m) on a side. The larger sizes are used where large amounts of air are needed.

The drier the outside air, the more moisture it will absorb. In the evaporator-cooler, moisture is provided by a moisture-laden pad. Air is sucked through the pad, usually by a squirrel-cage fan; moisture is absorbed; the air is cooled, and forced throughout the building in ducts, then out of the rooms through an exhaust opening. A slight air pressure will build up in the ducts. The usual back pressure is in the neighborhood of 1/20th to 1/10th in. of static water pressure. To reduce this as much as possible the outlet area in the room or building should be about three times the area of the cooler exhaust area. A more common method is to use exhaust fans. The slight back pressure will offer resistance to the fan in the evaporator-cooler causing the fan to move only about 85% of its maximum amount of air.

When fans are used to exhaust air: To maintain an equilibrium between incoming and outgoing air, the capacity of the exhaust fans should be about 10% greater than that of the intake fans, thus creating a negative pressure in the rooms.

Requirements of pad materials in the evaporator cooler The pad material should be

able to absorb water,
finely divided,
free from objectionable odors when wet,
free from corrosive or discoloring compounds,
free from grease and oil,
of minimum weight,
of maximum strength and flexibility,
resistant to decomposition during use,
of low initial cost,
easily maintained in place

Although many materials have been used for constructing pads, the ideal has not been found Aspen excelsior seems to be most applicable, and it is the material most often used

TABLE 5 6

TEMPERATURE REDUCTION THAT MAY BE ACCOMPLISHED WITH EVAPORATIVE COOLING WHEN DRY BULB TEMPERATURE AND RELATIVE HUMIDITY ARE KNOWN

Dry Bulb °F	°C	Percent Relative Humidity												
70	21 1	86	77	68	59	51	44	36	29	22	15	9	3	0
72	22 2	86	77	69	61	53	45	38	31	24	18	12	6	0
74	23 3	86	78	69	61	54	47	39	33	26	20	14	8	3
76	24 4	87	78	70	62	55	48	41	34	28	22	16	11	5
78	25 6	87	79	71	63	56	49	43	36	30	24	18	13	8
80	26 7	87	79	72	64	57	50	44	38	32	26	20	15	10
82	27 8	88	80	72	65	58	51	45	39	33	28	22	17	12
84	28 9	88	80	73	66	59	52	46	40	35	29	24	19	14
86	30 0	88	81	73	66	60	53	47	42	36	31	26	21	16
88	31 1	88	81	74	67	61	54	48	43	37	32	27	22	18
90	32 2	89	81	74	68	61	55	49	44	39	34	29	24	19
92	33 3	89	82	75	68	62	56	50	45	40	35	30	25	21
94	34 4	89	82	75	69	63	57	51	46	41	36	31	27	22
96	35 6	89	82	76	69	63	58	52	47	42	37	32	28	24
98	36 7	89	83	76	70	64	58	53	48	43	38	34	29	25
100	37 8	89	83	77	70	65	59	54	49	44	39	35	30	26
102	38 9	90	85	78	72	67	62	56	51	46	42	36	32	28
104	40 0	90	85	78	72	67	62	56	52	47	43	38	33	29
106	41 1	90	85	78	73	67	62	57	52	47	43	39	34	30
108	42 2	90	85	78	73	67	62	57	53	48	44	40	35	32
110	43 3	91	85	79	73	68	63	57	53	49	45	41	37	33
		Potential cooling for a given temperature and relative humidity[1]												
		Degrees Fahrenheit												
		3	5	7	9	11	13	15	17	19	21	23	25	27
		Degrees Centigrade												
		1 7	2.8	3 9	5 0	6 1	7 2	8 3	9 4	10 6	11 7	12.8	13 9	15 0

[1]This amount is theoretical. Approximately 80% of this change is accomplished in usual practice For example when the dry bulb temperature is 100°F and the relative humidity is 30% the table shows a 25°F potential drop In practice 80% of this or 20°F can be readily accomplished.

Location of the cooler: Smaller coolers should be installed on the side of the building and the air blown directly into small rooms. For larger installations however, where the air is ducted inside the building, the most common place for the cooler is at, or near, the peak of the roof.

How much can air be cooled? The amount of cooling by an evaporator-cooler depends on the temperature and relative humidity of the incoming air. Using Table 5.6 it is possible to calculate the cooling effect when the outside temperature and percent relative humidity are known.

Directions for using Table 5.6: To arrive at the temperature reduction, first find the outside temperature in the left-hand column, then go horizontally to the right until the percent relative humidity of the outside air is found. Follow this column to the bottom of the table where the temperature reduction is given.

Specifications for Evaporator-cooler: Some specifications for representative evaporator-coolers are given in Table 5.7.

TABLE 5.7

EVAPORATOR-COOLER SPECIFICATIONS

Width In.	Depth In.	Height In.	Outlet Velocity Ft per Min	Air Delivery Cfm
27	27	25	1300	2300
34	28	30	1750	3100
34	42	42	2500	5600
38	45	42	2400	7700
56	56	60	1980	9100

Evaporator-coolers in humid areas: When air expands during the hotter hours of the day, as during the afternoon, the percent relative humidity of the air is reduced, and it is able to absorb more moisture than during the cooler hours, as at night. Thus, when temperatures are highest, evaporator-coolers will reduce the temperatures more than when they are lowest. Because of this, coolers may be used in rather humid climates; their use cannot be confined to arid areas. In fact, the relative humidity during the afternoon hours may be as much as 20% less than during night-time hours.

Heating and Cooling in the Same Ventilating System

When ducts are used to transfer air to the hatchery rooms it is common practice to install both heating and cooling units in the same ventilating system. During cold weather, the heating unit operates; during hot weather, the cooling unit functions. A thermostat is installed in the respective room and adjusted so that the transfer from one unit to the other will take place automatically.

HUMIDITY IN THE HATCHERY

As a general rule there should be a high degree of humidity in the air of hatchery rooms. There are several reasons:

(1) Eggs in the egg holding room do not dry out as rapidly.
(2) Incubators operate more uniformly.

(3) Chicks in the chick holding room do not dehydrate as rapidly
(4) Room fumigation with formaldehyde gas is more efficient

Ability of Air to Hold Moisture

When a given amount of air is heated it expands, and its capacity to hold moisture is increased Thus, when air temperatures increase, relative humidities decrease The opposite is true when temperatures are reduced

Figure 5 2 is a nomograph used for calculating the change in relative humidity when the air temperature is increased or decreased

Question If the air temperature is 70°F (21 1°C) and the relative humidity is 75%, and the air temperature is raised to 100°F (37 8°C), what will be the relative humidity of the air?

Calculation Lay a ruler across 70°F (21 1°C), Line B, and 75% relative humidity, Line C, and find the intersecting point on Line A Hold the point on Line A and move the other end of the ruler up to 100°F (37 8°C) The ruler now intersects Line C at 30% relative humidity, the answer to the problem

Practical example A practical example could arise when the air in the incubator *room* has a temperature of 70°F (21 1°C) and a relative humidity of 75% When the air is drawn into the *incubators* and is heated to 100°F (37 8°C), the relative humidity drops to 30% This clearly indicates why additional humidity must be supplied in the incubators even though the relative humidity of the *room* seems more than adequate to meet the 50 to 60% required for egg incubation

HATCHERY DEBRIS

Sanitation plays an important part in the operation of a hatchery It is a must Floors, walls, and air must be kept clean, incubators scrubbed and disinfected, and debris collected, and either removed or incinerated As the amount of residue from hatcheries is tremendous, the question of how to handle it arises Some points of importance are

(1) Keep the material in a damp condition when floors and incubators are being cleaned, in order to keep as much of it out of the air as possible
(2) Do not sweep debris, vacuum it Keep each room isolated All material should be placed in a sealed container before moving it through rooms
(3) From the standpoint of disease organisms, the washroom is probably the most contaminated room in the hatchery Do not track from it to freshly cleaned rooms
(4) Use chick down collectors of one type or another over the exhausts from the chick hatchers, and from the chick holding room
(5) There are two alternatives for waste removal
    (a) Incinerate the material
    (b) Place it in bags of plastic (or similar material) and remove it from the hatchery
(6) Clean and sanitize the hatchery thoroughly When in doubt, sanitize again

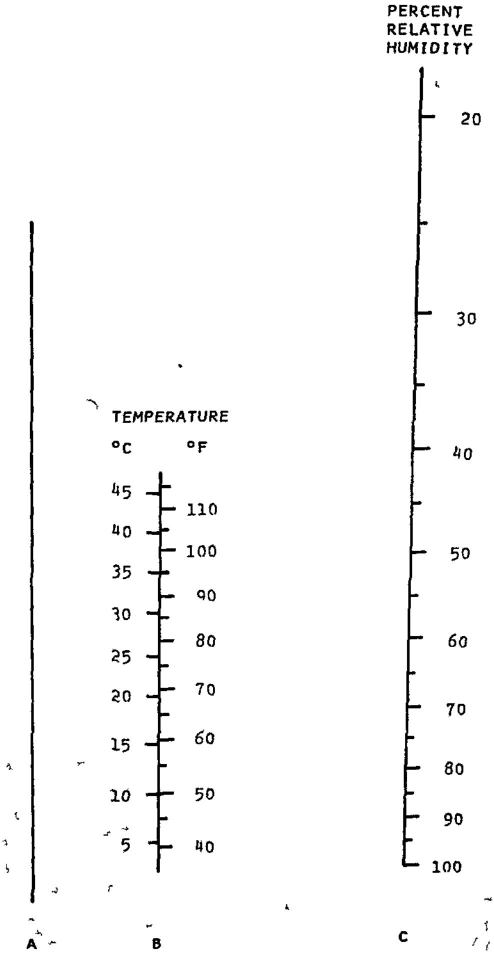

FIG 5 2 TEMPERATURE CHANGE AND ITS EFFECT ON RELATIVE HUMIDITY

HATCHERY OFFICE

A small office for certain hatchery personnel should be incorporated in the building plans. However, it is impractical to have a large office, open to the general public. Rigid isolation of the hatchery and disease-control programs make this unacceptable. The small office is for only those who have come through the hatchery shower. A general office should be a separate unit, constructed outside the restricted area of the hatchery.

Hatchery Equipment

Good equipment plays an important part in increasing hatchery profits. Not only will the hatchability of the eggs be improved, but the labor cost will be lower. Both are involved with profits.

Many pieces of hatchery equipment are necessary to complete the handling of incoming eggs, hatching the chicks, and preparing them for delivery. But the size and number of these pieces of equipment cannot be standardized for all hatcheries. Many factors are involved:

(1) size of the hatchery;
(2) number of days per week that hatches are to be taken off;
(3) type of disease-control program involved;
(4) whether breeder chicks or commercial chicks are hatched;
(5) type of incubators;
(6) hatchery services, as debeaking, sexing, dubbing, to be completed.

GENERAL EQUIPMENT

Water Softeners and Filters

An analysis of the water to be used in the hatchery should be made. If the mineral percentage is high, a water softener may be necessary. Excessive minerals in the water will cause deposits on the humidity controls and jets, making them inoperative in a relatively short period. Valves will not seat properly, and they will leak.

Water Heaters

The demand for hot water in the hatchery is great. Showers for the employees, and hot water for equipment used for washing and disinfecting call for large amounts of hot water. Industrial-type heaters, with a large capacity, should be installed.

EGG-HANDLING EQUIPMENT

Reducing the labor cost in the hatchery calls for the use of many labor-saving devices.

Hatchery Carts

Egg cases, egg flats, and chick boxes should not be handled any more than is necessary. Carts of several types may be used to expedite the transfer of these from one area of the hatchery to another.

Four-wheel carts: These come in several sizes, have four ball-bearing wheels, are usually constructed of angle iron, and have no platform. They are used to transfer egg cases, flats, and chick boxes. Typical sizes and capacities are given in Table 6.1.

Semilift carts: Larger carts are constructed with two heavy-duty wheels at one end and two legs at the other. A lift jack may be attached to the end with the legs to move the cart about. These are 4 or 5 ft (122 to 152 cm)

TABLE 6 1

DIMENSIONS AND CAPACITIES OF HATCHERY CARTS

Length		Width		Capacity		Approximate Number 30-Dozen Cases of Eggs
In	Cm	In	Cm	Lb	Kg	
16	41	24	61	250	113	5
24	61	24	61	300	136	6
25	64	25	64	700	318	14
22	56	32	81	900	408	18

long, and 26 to 28 in (66 to 71 cm) wide, with a platform They have a capacity of 20 to 25 30-dozen cases of eggs, or 1,200 lb (544 kg) Because it is more difficult to move them they usually are not used for transporting chick boxes

Hand trucks These are light weight trucks with two wheels and a long handle The added handle length is necessary to accommodate heavy loads such as egg cases Four egg cases, one on top of the other, may easily be handled on one truck The weight capacity is usually 250 lb (113 kg)

Conveyors

Removing cases of eggs from egg-delivery trucks and loading chick boxes into chick-delivery trucks sometimes may be expedited by using roller type or belt type conveyors The latter are usually motorized Conveyors are manufactured in many lengths and widths, they are light in weight, and some are made so that two or more lengths may be fastened together They are a great help in reducing the hatchery labor requirement, and in making it possible to move a large number of eggs rapidly and with little physical effort

EGG GRADING AND WASHING EQUIPMENT

In many hatcheries it is necessary to grade the eggs for size before they are set, in others, only a few are graded, and in some, such as commercial broiler hatcheries, they are not graded If they are to be graded, automatic graders are employed There are many of these on the market, of various types and capacities One should be secured that will do the job adequately in a limited amount of time

How egg graders are rated for size Most egg graders are rated according to the number of 30-dozen cases of eggs that can be run through them in one hour These ratings are for continuous operation, a feat not generally accomplished Under practical usage 85% of the rating would be a more accurate capacity Some indication of the size necessary may be found in Table 6 2

Incorporating Egg Washing

If it becomes necessary to wash hatching eggs, an automatic egg washer may be placed in operation just prior to the egg-grading process Eggs are run through the washer and directly onto the grading equipment without additional handling The

TABLE 6.2

HOURS NECESSARY TO GRADE EGGS

Number of Eggs to be Graded	Capacity of Grader in 30-Dozen Cases per Hour					
	5	10	12	15	20	35
10,000	5.6	2.8	2.3	1.9	1.4	0.8
20,000	11.1	5.6	4.6	3.7	2.8	1.6
40,000	22.2	11.1	9.3	7.4	5.6	3.2
80,000	44.4	22.2	18.6	14.8	11.1	6.4
160,000	88.9	44.4	37.0	29.6	22.2	12.7

capacity of the two units must be identical. Eggs should be dry at the time they pass to the grader to prevent dust rings from forming on them.

Vacuum Egg Lifts

To expedite the removal of eggs from egg flats, vacuum egg lifters should be used. Most of these lift the eggs by suction, but some less expensive ones have spring wires that clamp on the eggs. The lifters are operated by a vacuum pump which creates a suction on rubber nipples, the number varying from 12 to 48. Most of those used in hatcheries are 6 × 6. That is, they lift eggs from filter flats that are in rows 6 eggs long and 6 rows wide, lifting 36 eggs at a time. Some are larger (6 × 8) lifting 48 eggs. The size of the lifter is determined by the size of the egg flat used for collecting eggs and delivering them to the hatchery. The vacuum pump should be ample to operate the lifter. In larger hatcheries, 2 or more lifters are operated by 1 pump.

Where egg lifters are used: Egg lifters are used to reduce labor in the hatchery by making it possible for one operator to transfer many times the number of eggs as he could individually move by hand. Lifters may be used:

to transfer eggs from flats to washer;
to transfer eggs from flats to grader;
to transfer eggs from flats to incubator trays.

Note: Special lifters are employed for this last operation. These pick up the eggs, then narrow the distance between the rows of eggs so that the rows fit the incubator trays.

Washing Hatching Eggs

As a general rule, hatching eggs should not be washed. Washing usually reduces the number of chicks hatched from a given quantity of eggs. *This is true because:*

(1) the extra handling increases the number of cracked eggs;
(2) washing destroys the cuticle covering (bloom) on the outside of the shell, thus exposing more of the pores of the shell;
(3) it is difficult to keep the washwater purified to prevent eggshell contamination by disease-producing organisms.

Furthermore, the extra handling necessary to wash eggs is an additional hatchery labor expense.

However, on occasion, it may be necessary to wash eggs, particularly if they are very dirty. Certain solutions used for washing eggs also are used to destroy orga-

nisms on the eggshells, but when the washwater is recirculated it soon becomes contaminated

Detergents used for washing Most washing compounds have a detergent as their base There are many on the market Do not use laundry detergents As detergents have a tendency to foam, a compatible antifoaming solution is often added to the washwater

Hardness of water determines amount of detergent The more minerals in the water, the larger the amount of detergent necessary Water samples should be taken and analyzed to determine the exact quantity needed Water softeners may help in the presence of high percentages of minerals See Chapter 13

Disinfectants sometimes added to washwater To lower the level of disease producing organisms in washwater which is reused in the washing process, disinfectants are generally added A solution that releases chlorine slowly is an example

Caution If such disinfectants are used, care must be taken to keep them at a uniform level in the washwater Many are easily destroyed in the presence of organic material Some egg washers rinse the eggs with a chlorine solution after they have been through the washing section

Internal egg temperature rises during washing The water used to wash hatching eggs should have a temperature of about 110°F (43 3°C) Washing increases the internal temperature of the egg as much as 7° to 13°F (3 9°–7 2°C) Several factors influence the actual number of degrees

(1) temperature of the eggs prior to washing,
(2) size of the eggs,
(3) temperature of the washwater,
(4) length of time in the washwater

Plastic egg flats Some egg flats are made of plastic They are more durable than those made of fiber, and may be washed, disinfected, and reused

Some egg washers are made to accommodate eggs held on plastic flats Thus, there is no need to transfer the eggs from flats to the loading tray of the washer The trays and the eggs on them go through the washer together Furthermore, some incubators are manufactured so that plastic flats with eggs on them may be inserted in the incubator Again, there is no transfer of eggs at the time they are set Thus, a combination of washing and incubation of eggs may be accomplished with the eggs on the flats, without transfer Such a procedure reduces egg breakage because of less handling, and there is a material reduction in the cost of hatchery labor

Emergency Electric Standby Plants

When there is a failure in the outside electrical supply the hatchers must have a quick source of other electric power This is furnished by a standby plant, situated in or adjacent to the hatchery building If the regular electrical supply commonly fails for long periods it will be necessary to have a standby generator capable of supplying all the incubation equipment with electricity If short periods of electrical failure are the rule, only the hatchers need be supplied by the standby plant Other electric hatching equipment also may be connected, depending on requirements

What type plant? When the standby plant is to be used only in case of a failure of regular service, order a plant that matches the output of the commercial electrical supply. Consult an electrical engineer and your incubator manufacturer before you purchase.

Automatic or manual? With the automatic plant the transfer from the outside electrical supply to the standby unit is automatic. When the outside power fails, the motor used to operate the generator starts automatically, and switches transfer the load to the new supply of power. When the changeover is manual, the switches must be moved by hand, and the motor on the generator must be hand-started.

Important: For plants with manual controls, an alarm system should be installed. The alarm bell will ring automatically when the regular electric current ceases.

Calculate the electric load required: Before ordering a generator, calculate the electric load necessary when power fails. *Remember*, that most incubators have auxiliary heaters that operate after the incubators have been without electricity for a few minutes. This increases the load, often doubling it. Thus, the starting load is much greater than the normal operating requirement.

What type of fuel for generator motor? The type of fuel to be used to operate the generator motor will be based on:

(1) size of the generator to be operated;
(2) engine maintenance;
(3) cost of fuel;
(4) local fuel storage regulations;
(5) performance requirements;
(6) method of cooling the engine.

Gas and gasoline plants are similar and are used for smaller operations. Larger installations are often powered with a diesel engine.

INCUBATION EQUIPMENT

Incubators represent the most important equipment in the hatchery. Many kinds of incubators are manufactured; however, the general principles are the same with all modern machines:

(1) forced-draft air circulation;
(2) mechanical egg turners, usually operating automatically;
(3) automatic air-temperature control;
(4) automatic air-humidity control;
(5) a separate area for holding the eggs during the last three days of incubation, either within the same cabinet, or in a separate cabinet (separate hatcher);
(6) some device for controlling incoming and outgoing air.

Incubators Improved

Manufacturers have made improvements in their machines during the past few years. Many of these have been built around labor-saving principles. Some that should be studied prior to the purchase of any incubator are:

(1) *Improved cabinet materials*
Modern materials, that do not deteriorate in the presence of heat or moisture, are now being used

(2) *Better controls*
Controls have been modernized so that they maintain the temperature and humidity within closer variations

(3) *Elimination of need for traying eggs*
As a labor-saving element, some incubators are capable of handling hatching eggs on plastic flats Eggs usually are gathered on the flats, and the flats and eggs inserted in special racks in the incubators No extra egg handling is necessary to place individual eggs in the setting trays

(4) *More efficient cooling*
During periods of high temperature it is necessary to cool the interior of the incubator and hatcher Improvements have been made in cooling devices in incubators, but the importance of adequate cooling and ventilation during periods of hot weather still cannot be overemphasized

(5) *Floorless machines*
With many models, the floor section of the cabinet has been eliminated, and the walls sit directly on the hatchery floor This is particularly advantageous in the hatchers inasmuch as portable racks may be used to move the eggs into the machine, and the chicks out This also facilitates cleaning the inside of the cabinets

(6) *Egg transferring operation shortened*
Transferring hatching eggs from the setting trays to the hatching trays is a laborious process Improvements have been made in this operation

(7) *Incubator floor space decreased*
Improved interior design has, in many instances, reduced the amount of floor space necessary for the incubators Some machines are built around a flow through system, in which the eggs enter at one end of the cabinet, and the chicks are removed at the other Some are designed so that an upward extension of one wall of the incubator will provide a separate room, thus reducing the number of permanent walls in the hatchery

(8) *Cabinets hold more eggs*
Incubators are now manufactured in sizes larger than a few years ago This has increased the number of eggs per square foot of incubator floor space, thus decreasing the necessary hatchery floor space

(9) *Incubator cost*
Improved design, larger machines, and more efficient manufacturing methods have obviously had their effect on incubator cost, a major one in a hatchery

How to calculate cost The cost of incubators should be calculated as "cost per egg capacity " Other things being equal, this represents a determining factor in making a selection However, many

factors other than the cost per egg should enter into the final decision: mechanical features, ease of operation, maintenance, labor-saving devices, etc.

OTHER HATCHERY EQUIPMENT

There are many other items of equipment necessary to operate a hatchery efficiently, and to furnish services necessitated by customer request, such as sexing.

Egg Candlers

In some instances eggs are candled during the incubation period. Eggs that are infertile, and those in which the embryos have died, are removed. At times there is a market for the infertile eggs as food for human consumption.

Test Thermometers

Several highly accurate test thermometers should be a part of the hatchery equipment. These may be used for checking the accuracy of the thermometers in the incubators, setters, and hatchers.

Service Tables

Several movable tables equipped with casters should be provided for boxing chicks, sexing, and various other chores. The size of these tables will be determined by the type of hatchery operation involved.

Chick Box Racks

Although chick boxes filled with day-old chicks may be placed on dollies, some prefer to place the boxes in racks. These are built of 1- by 2-in. (2.5–5 cm) lumber and constructed so that each box has its own compartment with an air space between it and the neighboring boxes. Racks may be constructed to accommodate 6 to 8 tiers of boxes, and are generally 4 boxes long. Casters are used on the bottom of the legs to facilitate movement.

Chick Graders

When chicks are to be graded for quality, a chick grader will be of help. Such a grader consists of a movable belt about 18 to 24 in. (46–61 cm) wide that moves over a length of 6 to 8 ft (183–244 cm). Chicks are placed on one end of the belt, and hatchery personnel working from each side of the grader remove those chicks that meet the quality standards. The culls fall off the belt at the end of the grader and are collected in another box. Such chick-grading equipment may be secured from manufacturers.

Sexing Equipment

There are four common methods of sexing chicks at day old. The method used will determine the equipment necessary.

(1) *Vent sexing:* Most chick sexers furnish their own equipment which consists of only a bright light.
(2) *Machine sexing:* These are specialized sexing machines capable of visually observing the sexual organs of the chicks. These may or may not be supplied by the hatchery.

(3) *Color sexing* No equipment is needed other than suitable tables for holding the chick boxes.

(4) *Feather sexing.* Only tables for holding the chick boxes are needed

Vacuums

Hatchery dust should be vacuumed, not swept. Large, industrial-type vacuums should be used The size and number will be determined by the size of the hatchery operation. There are many on the market. Variations in their makeup are:

(1) *Self-contained, or conversion-covered, machines*
Self-contained units are complete, conversion units are made to be placed on top of a steel barrel.

(2) *Dry or wet-and-dry units*
Some vacuums pick up only dry material; others may be used with either wet or dry debris, and are preferable.

(3) *With or without dust collectors*
Dust collectors are usually bags that move with the machine, and are easily cleaned. Hatchery vacuums should employ some system of dust collection.

(4) *Portable hand units*
These are either smaller vacuums that may be carried, or those with smaller suction heads. They are helpful in cleaning the inside of incubators and other hatchery equipment

Pressure Pumps

Increased water pressure will be necessary to do a thorough job of washing the floors, walls, incubators, and hatching trays A pressure pump should be installed in the hatchery to give the necessary water pressure. These come in various sizes, and capacities, some are portable, and some must be permanently installed.

Tray Washers

Cleaning hatching trays is laborious when done by hand. To facilitate the procedure, an automatic tray washer may be used. Many are on the market. In some instances washers are matched with the make and size of the incubator tray used.

Room Air Circulators

If certain hatchery rooms are inadequately ventilated, or the air does not circulate completely, air circulators may be installed These are large tubes about 6 ft (183 cm) high with the same diameter as the fan to be inserted in the tube The fan is pointed so that the air is forced upward through the tube. Air is picked up from the floor, forced through the tube, exhausted at the top, then circulated throughout the room Some are equipped with a heating unit in the tube.

Dubbing Shears

Dubbing shears are small manicure scissors They are used for removing the combs of chicks at one day of age

Removing the Beak

An electric, automatic, or semiautomatic machine is used for removing a part of the beak. Although the procedure is recommended when chicks are 6 to 9 days

of age, customers sometimes request that the work be done at one day of age, in the hatchery. Two methods are available:

(1) *by hot, cauterizing blades*
Special machines are available for removing a portion of the beak and cauterizing the tissue.

(2) *by cold knives*
Similarly, specialized machines are available for cutting off a portion of the beak with cold knives. No cauterization is involved.

Detoers

Although a debeaker may be used to sever the ends of the toes of day-old chicks, a special detoer is more practical. It is composed of a transformer and two heat-resistant wires. The wires are arched at the end of two arms that may be squeezed together, thus bringing the wires in contact. Toes are placed between the hot wires, which, when brought together, remove the toe at the outer joint.

Automatic Syringes

Some hatcheries inject day-old chicks with vaccines or solutions involved with disease prevention. To facilitate the procedure the syringes are automatic; that is, they are capable of refilling automatically, and may be adjusted to allow varying dosages.

Mycoplasma Gallisepticum Test Equipment

As a part of a PPLO S-6 negative program the rapid serum plate test should be completed in the hatchery, using culled chicks, or chicks that have pipped the shell, in order to determine if antibodies are present. This requires

(1) small test tubes for holding the blood;
(2) testing plate and cabinet.

Note: Some testing cabinets utilize absorbent paper instead of glass. The test paper may be dried and filed for future reference. This is not possible when a glass plate is used.

Further reference: Refer to Chapters 9 and 41.

Maintaining Hatching Egg Quality

Maintaining the hatching potential of the newly produced egg is of vital importance But a lot can happen to a hatching egg between the time it is laid and the time it enters the incubator As a result of faulty egg handling during this critical period much of the inherent ability of the egg to hatch well and to produce a quality chick may be lost Every technique of good egg care and handling must be put into effect to prevent any possible loss of quality

MAINTAINING EGG QUALITY IN THE CHICKEN HOUSE

If over 2% of the eggs are cracked or broken between the time of being laid and the time they are set in the incubator, there is a real problem Normally there should be less than 1% If eggs are incubated on the flats on which they are gathered, the percentage should be even less

Nesting Material

Hatching eggs are valuable and egg breakage is costly Many eggs are broken in the nest as the result of inadequate cushioning effect of the nesting material But more important is the prevention of stained and dirty eggs as a result of unclean and wet nesting material Ability to absorb moisture is an important quality to consider in selecting a good covering for the bottom of the nest Common ones are

extruded volcanic ash
shavings
peat moss
rice hulls
peanut hulls
dried sugar cane
chopped corn cobs
straw, hay
excelsior nest pads

Nesting materials should be
absorbent
durable
coarse, so they will not easily be blown from nests
dust free
of good cushioning quality
inexpensive

Floor Eggs

Birds should be trained to use the nests rather than allowed to lay on the floor where a high percentage of the eggs will be broken Following these suggestions will induce hens to lay in the nests rather than on the floor

(1) Place the nests in the pen before the birds start laying
(2) Put the nesting material in the nests when the nests are placed in the pens Keep the nesting material clean before egg production starts Hens may refuse the nests if the nesting material is dirty or dusty
(3) Put nesting material in roll-away nests before the start of egg production,

and during early egg production. Pullets often refuse wire-floored nests, thus creating a habit of laying elsewhere.

(4) Provide adequate nesting material. If the material has been blown out of the nests, or worn out, and the bare surface of the nest floor is exposed, birds are not likely to lay in the nests.

(5) Block off corners of the pen where hens congregate and are likely to lay eggs on the floor. Do this prior to the start of egg production.

(6) Have enough nests. If birds cannot get into the nests to lay they will be forced to find a "nest" on the floor.

(7) Break up broody hens. They take up nesting space, forcing other hens to lay on the floor.

Collecting Hatching Eggs

Normally, hatching eggs are picked up from the nests four times each day. However, during periods of extremes in temperature, either high or low, 5 or 6 collections may be necessary. Frequent gathering of eggs decreases breakage in the nest and helps maintain hatching potential.

Important: Eggs laid late in the day should be collected the same day rather than left in the nests until the next morning. Hatching eggs left in the nests overnight will lose some of their hatching qualities. Shell sanitization of these eggs the day after laying rather than immediately after laying will be of little value in preventing the entrance of bacteria into the egg.

Close the Nests at Night

Hens should not be allowed to sit in the nests overnight. Close the openings after the day's egg production has been completed, first removing any birds inclined to want to remain in the nests. Open the nests early in the morning, before laying begins.

Egg Containers

The type of containers used for holding the eggs collected from the nests is important. Once laid, hatching eggs should cool gradually, not suddenly. Thus, they are best collected on egg flats. With some incubators, provision is made to leave the eggs on the same flats during incubation. When other incubators are used, the flats and eggs should be placed in new or clean (fumigated) egg cases.

Egg baskets not advised: Piling one egg on top of another in wire baskets (or buckets) will only increase breakage. Furthermore, eggs eventually must be removed from the basket to another container. The less handling the better.

Plastic flats better than fiber: Litter and dirt accumulate on fiber flats, and they cannot be washed. Select a plastic flat which will allow the litter to fall through.

If corrugated paper egg cases are used to hold eggs during the preincubation period, several holes about 2 in. (5.1 cm) in diameter should be cut on the sides of the cases. This allows movement of air through the cases, particularly important during any fumigation process. A polyethylene egg case also is available for storing hatching eggs.

When gathering eggs, separate the extra large, double-yolk, misshapen, and cracked eggs. Many hatcheries do not grade commercial hatching eggs for size, feeling that the benefits do not offset the expense involved. Removing the obvious nonhatching eggs in the hen house will improve the procedure if eggs are not to be graded for size.

When hatching eggs are to be held from the day of lay until they are placed in the incubator, they should always be packed with the small end down. Reversing the procedure adds to the incidence of tremulous air cells and embryonic malpositions during incubation, and thus reduces the percentage of hatchability.

REDUCING BACTERIAL CONTAMINATION OF EGGS

The outer surface of the eggshell is never sterile. Even at the time the egg is laid the shell has become contaminated by excretions of the urinary and digestive tracts. Although by surgery eggs can be removed from the oviduct, most of those so removed will show bacteria on the shell. Bacteria grow on the shell rapidly after the egg is laid, the rate depending on temperature and humidity. The following shows an average example:

Age of egg	Number of bacteria on the shell
Fresh-laid	100–300
15 minutes	500–600
1 hour	4,000–5,000

Effect of Poultry House on Eggshell Contamination

Quarles, C. L. *et al.* 1970 (*Poultry Sci.* *49*, No. 1, 60) reported the following information, comparing a poultry house with a littered floor with one with a wire floor:

(1) A litter-floor house averaged approximately nine times as many bacteria in the air as a wire-floor house; fungal organisms were approximately the same.
(2) Bacterial count on eggshells produced in a litter-floor house were 20 to 30 times greater than on eggs produced in a wire-floor house.
(3) The presence of coliform bacteria in embryos and chicks was related to the bacteria concentration in the air in the poultry house.

The quality of any sanitizer may largely be based on the ability to administer it as soon as possible after the egg is laid, before there is any shell penetration by bacteria. From a practical standpoint eggs are picked from the nest about every 2 or 3 hours. During this time the increase in numbers of bacteria on the shell has been tremendous; some have penetrated the shell. Obviously, shell sanitizers cannot offer complete kill; because of delay in administering even the best are none too good. Refer to Table 7.1.

TABLE 7.1

EGGSHELL DECONTAMINANTS AND THEIR EFFECT

Treatment	% Hatch-ability	Shell Bacterial Growth*	Egg Content Bacterial Growth*
None	83.4	4	3.8
Formaldehyde	83.8	2	2.8
Quaternary ammonia	84.2	2.3	2
Chlorine dioxide	84.6	1	1

*Score #1—low; #4—high
Source: C. K. Quarles and C. Lewis, Indian River Poultry Farms, Lancaster, Penn.

Summary of research findings:

(1) Chlorine dioxide improved hatchability, reduced shell bacteria and internal bacteria the most.
(2) Under high concentrations of formaldehyde hatchability of white eggs was impaired less than brown eggs.
(3) Formaldehyde deposit on eggshells decreased rapidly during the first 2 hours after fumigation, but some remained for as long as 21 days.
(4) The full effect of sanitizing eggs could not be accomplished unless the eggs were less than 30 minutes old. After that time there was some shell penetration by bacteria.

Eggshell Penetration by Bacteria

The outer porition of the egg has three coverings: (1) shell, (2) outer-shell membrane, and (3) inner-shell membrane. Each acts as a barrier to foreign penetration, bacteria being the most important of the group. These three coverings rank in penetration prevention as follows:

(1) Shell plus cuticle	best
(2) Inner-shell membrane	second best
(3) Outer-shell membrane	poorest

Each covering acts as a filter; but none has any bactericidal properties. In spite of these protective coverings, some bacteria do find their way into the egg contents. No doubt this entrance is made possible by shrinkage of the egg contents as they cool; this creates a slight vacuum inside the shell, and bacteria are "sucked" through the pores of the shell and shell membranes.

Important: The only method of preventing shell penetration by bacteria is to destroy the bacteria immediately after the egg is laid, before shrinkage of the egg contents begins. At least the sanitizing should be completed

When gathering eggs, separate the extra large, double yolk, misshapen, and cracked eggs. Many hatcheries do not grade commercial hatching eggs for size, feeling that the benefits do not offset the expense involved. Removing the obvious nonhatching eggs in the hen house will improve the procedure if eggs are not to be graded for size.

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Eggshell Sanitizers

More organisms attach themselves to the shell while the egg is in the nest. Many times this build up of organisms, particularly the bacterial, will have an adverse effect on hatchability, chick quality, and chick livability. To prevent this, hatchery men usually go through a process of shell decontamination. Fumigants, sprays, or solutions are used. Their practicability varies.

Types of sanitizers

Formaldehyde gas

Can be used at 1X (single strength) to 5X concentration. 3X is usually recommended.

Quaternary ammonia

Sprayed on eggs in a *lukewarm* water solution containing 200 ppm

Chlorine dioxide

Sprayed on eggs in a *lukewarm* water solution containing 80 ppm

The quality of any sanitizer may largely be based on the ability to administer it as soon as possible after the egg is laid, before there is any shell penetration by bacteria. From a practical standpoint eggs are picked from the nest about every 2 or 3 hours. During this time the increase in numbers of bacteria on the shell has been tremendous; some have penetrated the shell. Obviously, shell sanitizers cannot offer complete kill; because of delay in administering even the best are none too good. Refer to Table 7.1.

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Important: The only method of preventing shell penetration by bacteria is to destroy the bacteria immediately after the egg is laid, before shrinkage of the egg contents begins. At least the sanitizing should be completed

immediately after each egg pickup It should be done in the poultry house Do not wait until the eggs are removed to a central location

Be careful of recontamination After shell sanitizing, eggs should not be allowed to become recontaminated by exposure to bacterial reinfestation This can be as detrimental as not sanitizing If there is a chance of recontamination, hatching eggs should be resanitized at the entrance to the hatchery building

Producing Eggs Under MG negative and MS-negative Programs

This calls for certain procedures necessary to produce hatching eggs that are *Mycoplasma gallisepticum* PPLO S-6 negative or MS negative (Refer to Chapter 9 and Chapter 41, sections on Mycoplasma Gallisepticum and Mycoplasma Synoviae, for details of such a program)

TRANSPORTATION OF HATCHING EGGS

The poultry breeding farm or farms are often located some distance from the hatchery building, making it necessary to transport eggs a considerable distance In such instances eggs are most easily kept in conventional egg cases containing flats, or flats and fillers Regardless of the distance to the hatchery building, or the number of days eggs are to be held on the farm before being taken to the hatchery, they should be resanitized at the entrance to the hatchery

Optimum holding requirements The temperature should be 65°F (18 3°C) and the relative humidity 75 to 80% Most eggs are transported by truck but occasionally hatching eggs are moved long distances by air Although such transportation will not normally affect the hatchability of eggs through jarring, shaking, or altitude, the time involved in making the transfer from one point to another, and any variation in the environmental temperature outside the limits of normalcy will affect the hatchability

EGG QUALITY AND HATCHABILITY

Hatching eggs of poor quality do not hatch as well as eggs of good quality The term "quality" refers to the condition outside the shell, the condition of the shell itself, and that of the contents Eggs with inferior characteristics should be eliminated rather than be placed under incubation Some obvious physical differences of eggs and their effect on hatchability are described below

Size of Eggs

Within a given group of eggs the very small ones and the extremely large ones do not produce as satisfactory a hatch as do those of normal size Extremely large eggs, eggs with double yolks, and extremely small eggs should not be set The incidence of these will vary according to the length of time the flock has been producing eggs More double-yolked eggs will be produced at the beginning of the laying period than later

When to place more emphasis on egg selection Hatching eggs which are used for the production of breeding stock should be more carefully selected than those used to hatch commercial broiler chicks and commercial layer chicks

Shape of Eggs

Eggs that are shaped other than normal have a lower hatchability than that of normal eggs. Many of these misshapes are inherited and should not be placed in the incubator, in order to reduce their incidence in the next generation Poor interior quality of the egg also affects hatchability. Table 7 2 shows the effect when eggs with abnormalities are set.

TABLE 7 2

HATCHABILITY OF NONNORMAL EGGS

	% Fertility	% Hatchability of Fertile Eggs	% Hatchability of All Eggs
Normal eggs	82 3	87 2	71 7
Cracked eggs (small checks)	74 6	53 2	39 7
Misshapen eggs	69 1	48 9	33 8
Poor shells	72 5	47 3	34 3
Loose air cells	72 3	32 4	23 4
Misplaced air cells	81 1	68 1	53 2
Large blood spots	78 7	71 5	56 3

Source M W Olser and S K Haynes 1949, *Poultry Sci* 28, 420–426

Color of Shell

The density of the pigment in brown-shelled eggs is often correlated with hatchability When a group of brown-shelled eggs from a single flock of birds is being hatched, those with darker shells will hatch better than those with lighter shells. However, because high hatchability is a genetic factor, strains of chickens may be developed that produce high or low hatchability irrespective of eggshell color. Thus, strains of chickens laying eggs with light-brown shells would not necessarily involve poor hatchability.

Shell Quality

Eggs with poor shells, those that are porous, white or chalky, do not hatch well. Not only is shell quality an inherited factor, but it is dependent upon the nutrition of the dam and the environmental temperature under which the dam is kept Diets low in calcium and vitamin D, and continuous environmental temperatures above 80° to 90°F (26.7°–32.2°C) are conducive to the production of eggs with inferior shells. Furthermore, the longer a hen remains in egg production the greater the deterioration in shell quality. The incidence appears earlier during the second period of egg production (after force molting) than during the first period.

Recommendation· Flaky-white eggs and other eggs with inferior shells (ridged, thin-shelled) should not be set They hatch very poorly, and the risk of breakage during handling and incubation is too great

Thick and Thin Albumen.—Large eggs contain a higher percentage of thick white than small eggs. This has a practical application because as the proportion of thick white increases, hatchability decreases.

There is also a relationship between the surface area of the shell of the egg and the egg contents. The surface area of an egg, in relationship to its contents, decreases as the egg increases in size or weight. As there is a constant loss of mois-

ture through the shell during incubation, small eggs evaporate more rapidly than large eggs because of this relationship In fact this difference in evaporation may become so great that a serious problem may arise *Note*

Chicks from small eggs are smaller than normal
Small eggs hatch earlier than normal, large eggs hatch later
Small eggs should be set later, large eggs earlier than is normal for the average of the group

Interior Quality—Some eggs are laid with tremulous air cells, others incur them later through jarring and improper handling These air cells present one of the greatest depressors of hatchability and the difficulty is much greater than thought heretofore

Caution Hatching eggs should be handled carefully Tremulous air cells are easily produced Prevent jarring and be sure eggs are packed with the small end down The air cell becomes more tremulous when the large end is down

Position of the Egg in the Clutch and Hatchability

There is some evidence not only that eggs laid in longer clutches (consecutive days on which eggs are laid) have higher hatchability, but that those laid near the end of the clutch hatch better than those laid at the first of the clutch This fact has no practical application in the operation of a poultry breeding farm, but it does indicate one reason why eggs from high producing hens generally have greater hatchability

Weather and Hatchability

Lower hatchability from eggs laid during periods of extremes in environmental temperatures is common Continuous days of hot or cold weather are likely to cause a drop in hatchability, but periods of short duration (1 or 2 days) will not The difficulty is the result of

(1) Decreased feed consumption, causing nutritional inadequacies
(2) The fact that egg hatching quality deteriorates more rapidly during the pre incubation (holding) period

FACTORS AFFECTING LENGTH OF INCUBATION PERIOD

Although the normal average incubation period for a chicken egg is 21 days this figure is highly variable In fact, the variation may become so great at times as to affect the normal routine of hatchery labor and to lower the chick quality

Eggs should be set at a time planned so that all chicks will hatch within a short period of time This makes it easier to take off hatches, and to grade box, and deliver the chicks The following factors are involved

(1) Eggs laid in the warmer season have a shorter incubation period than those laid in the colder season This is the result of preincubation of the eggs which have been held at high temperatures during the period before they are placed in the incubator
(2) The longer eggs are held in the cooler room prior to setting in the incubators the longer the incubation period
(3) Leghorn eggs have a shorter incubation period than those produced by meat type birds

(4) Small eggs hatch sooner than large eggs.
(5) Eggs laid early in the laying period require fewer hours of incubation than those laid near the end of the laying period.
(6) Eggs with thick shells require a longer incubation period than those with thin shells.

HANDLING EGGS PRIOR TO INCUBATION

Proper handling of eggs prior to incubation is important if the highest hatchability is to be attained. The many factors involved are described below.

Egg-holding Room

Eggs should be moved to the cooling room (egg-holding room) soon after they are received at the hatchery; but they should not be allowed to stand unprotected in the holding room. They should be placed in corrugated or wooden cases with holes cut in the sides, or on flats, which should be covered. The essence of good cooling of hatching eggs is not to reduce the temperature too rapidly. Remember that the embryo of a freshly laid hatching egg already has undergone several hours of incubation and consequently is a living organism sensitive to sudden extremes in temperature.

Egg-holding room temperature: Although the optimum temperature for embryonic development in forced-draft incubators is in the neighborhood of 99.5°F (37.5°C), this does not mean that there is no embryonic growth above or below this figure. There is a "threshold" temperature above which embryonic growth commences, and below which it ceases. Originally this temperature was thought to be 68°F (20°C), but more recent research work has given some indication that under controlled conditions this may be as high as 75°F (23.9°C).

Inasmuch as the embryo in a newly laid egg is slightly cold-blooded (similar to reptiles), one may alter its environmental temperature above or below the threshold area several times before the embryo is completely killed. However, each time the temperature goes above or below the threshold the embryo grows weaker and its chance for hatching decreases.

Correct holding temperature: After hatching eggs are laid they should be cooled to a temperature well below the threshold of embryonic development and kept at this temperature until shortly before being placed in the incubators. Temperature in the egg-holding room should be 65°F (18.3°C) to curtail embryonic development adequately. When eggs are held at a temperature lower than this, hatchability will suffer.

Although the above is a practical application of correct temperature, there is some indication that when eggs are held for more than 14 days, 51°F (10.5°C) will produce better results.

Lowering Egg Temperature During Holding Period

Although it is recommended that hatching eggs be held at a temperature of 65°F (18.3°C) prior to incubation, reduction of the actual temperature of the egg from the body temperature of the hen of 105°F (40.6°C) should be gradual, taking about one day, to preserve the potentiality of the living embryo. Eggs may cool too rapidly, while at other times the cooling process may be too slow.

TABLE 7.3

TIME TO COOL EGGS TO 65°F (18 3°C)

Time Required to Cool Eggs in Containers from 90°F (32 2°C)			
Sealed Egg Cases	Egg Cases with Holes in Side	Wire Baskets	Incubator Egg Trays
4-5 days	1-2 days	1 day	3/4 day

Some of this difference may be attributed to the container in which the eggs are stored during the holding period Some examples are shown in Table 7 3

The above figures for egg cases are representative when the cases are stored with air movement between them If the cases are stacked close together, without air movement, the time necessary to cool eggs will be longer

How to do it Use egg cases with holes in the sides, and stack the cases so as to provide air movement between them Do not use wire baskets or incubator egg trays unless they are covered to prevent excessive air movement

Egg holding room humidity Moisture held within the contents of the egg is continually lost by evaporation through the shell The rate of this process is governed in part by the relative humidity of the air surrounding the egg, when this is low, evaporation of the egg contents is more rapid, when it is high, evaporation is less rapid

During the holding period, evaporation of the interior portion of the egg should be held at a minimum by increasing the humidity of the air in the egg holding room To completely surpress egg evaporation by this method seems impractical because the humidity would have to be raised to near the saturation point Cardboard egg cases then become saturated with moisture and are impossible to handle

Correct humidity in egg holding room The relative humidity of the air in the holding room should be 75 to 80% This materially reduces egg evaporation and does not cause too much egg-case deterioration

Length of Time to Hold Hatching Eggs

When hatching eggs are held at a temperature below the threshold, embryonic development is arrested However, hatchability decreases for each day the eggs are held Eggs held for less than five days show little perceptible reduction in their hatchability or in the quality of the chicks hatched from them But when the period of holding is longer than five days, hatchability will drop materially

Under commercial conditions eggs are set at least twice a week Thus, some of the eggs would be 3 days old, some 2, and some 1, and there would be little discernible loss in hatchability of the group But on occasion eggs are held longer before being placed in the incubator

Holding eggs for long periods not only reduces the hatchability as shown in Table 7 4, but increases the length of the incubation period

Rule of thumb Hatching time is delayed 20 minutes and hatchability is reduced 4% for each day eggs are held or stored after 5 days

Important If eggs are produced and stored over a 14-day period some will be 1 day old, some 14 days The average will be 7 days

TABLE 7.4

EFFECT OF NORMAL EGG STORAGE ON HATCHABILITY AND INCUBATING PERIOD

Days of Storage	Hatchability of Fertile Eggs %	Hatching Time as a Delay from the Normal Hours
1	88	0
4	87	0.7
7	79	1.8
10	68	3.2
13	56	4.6
16	44	6.3
19	30	8.0
22	26	9.7
25	0	11.8

Holding Eggs for Long Periods in Plastic Containers

To prevent rapid loss of moisture from hatching eggs stored for long periods, a liner of plastic (or similar material) may be used inside the egg cases. These are usually sealed to make them air-tight. For further preservation of egg quality nitrogen gas may be flushed into the egg area before sealing. After a few hours in the lined cases, moisture escaping from the eggs will raise the humidity. This, in turn, aids in slowing further egg evaporation. Such a method will:

prolong the hatching quality of the eggs;
increase the hatchability;
not be detrimental to the chicks hatched from such eggs;
not alter first-year production from birds hatched from eggs undergoing the treatment.

Procedure:

(1) Disinfect the eggshell.
(2) Cool the eggs thoroughly to 65°F (18.3°C). Both (1) and (2) are necessary to help prevent mold from growing on eggs stored in the humid, airtight, plastic containers.
(3) Place eggs in egg cases with plastic containers, flush with nitrogen and seal.
(4) Store eggs at 65°F (18.3°C).

Turning Hatching Eggs During the Holding Period

When hatching eggs are held for less than one week before being set there seems to be no need for turning them during this period. However, in the case of certain poultry breeding and genetic farms, it may be necessary to hold eggs for rather long periods. Rotating eggs from side to side over a 90° angle will then improve hatchability.

How to turn the eggs during the holding period: Place the eggs in an egg case and place a 10-in. (25-cm) block under one end. The next day, remove the block and place it under the other end.

Cleaning Hatching Eggs

Eggs that become soiled do not hatch well, the remedy lies in the chicken house and not in the holding room after the eggs are collected. Following are some of the common causes.

(1) improper nesting material (not absorbent)
(2) dirty nesting material
(3) wet litter causing feet of the birds to become dirty
(4) floor eggs
(5) eggs broken in the nests
(6) eggs laid on slat or wire floors rather than in the nests

Washing eggs, even under the best of modern conditions in an automatic washer with detergents added to the washwater, usually lowers hatchability. Washing is not recommended, but if it is done special care must be taken to keep the wash water clean. Unless the water is changed often it may only increase the transfer of disease producing organisms from one egg to another.

Moisture Condensation on Eggshell

When eggs are removed from a cold room to a room with a higher temperature, as moving eggs from the cool egg holding room to the egg traying room, moisture will often condense on the shells, this picks up additional bacterial organisms floating in the air and increases shell contamination. Furthermore, such moisture makes eggs hard to handle and they are easily soiled.

Table 7.5 shows the temperature and relative humidity at which eggs will "sweat" (condense moisture on the shell).

Remedy for moisture condensation. If moisture is condensing on the shells when the eggs are moved from the egg-cooler room to the egg traying room, there are two remedies.

(1) Decrease the relative humidity in the egg traying room. This may be difficult, and even impractical.
(2) Increase the temperature in the egg traying room. When tempera

TABLE 7.5

EFFECT OF HUMIDITY AND TEMPERATURE ON MOISTURE CONDENSATION ON EGGSHELLS

Egg traying Room Temperature °F	°C	Temperature of Eggs (or Temperature of Cooler) 55°F (12.8°C)	60°F (15.6°C)	65°F (18.3°C)
		Eggs will Sweat if Relative Humidity in Egg Traying Room is Higher than %	%	%
60	15.6	82	—	—
65	18.3	70	85	—
70	21.1	58	71	83
75	23.9	50	60	71
80	26.7	42	51	60
85	29.4	36	44	51
90	32.2	30	37	43
95	35.0	26	32	38
100	37.8	22	28	32

ture is increased, the relative humidity decreases, thus preventing condensation of moisture.

Caution *Never fumigate moisture-laden eggs with formaldehyde gas All eggs must be dry before the fumigation process is initiated*

GRADING AND TRAYING HATCHING EGGS

If it is necessary to sort hatching eggs by size, the process should be completed after the eggs have cooled in the egg-holding room. The usual procedure is to grade and tray eggs as close to setting time as possible. When there is a uniform daily labor supply in the hatchery this may not be practical, and eggs may have to be trayed daily and ahead of setting time If this is the case the trayed eggs should be placed in cabinets, and the cabinets covered. Do not allow hatching eggs to be located in free-flowing air as in front of fans Increasing the flow of air around eggs increases the rate of egg evaporation, and thus dries out the contents more rapidly.

Egg grading increases cracked eggs Each handling increases the number of cracked eggs Do not grade eggs unless absolutely necessary.

Most broiler hatching eggs not graded With integration in the broiler industry there is little advantage in making a close selection of hatching eggs for quality and weight Integrators feel it is more profitable to set eggs without grading than to go to the expense of the necessary handling. But this does not necessarily mean that some minimum weight of hatching eggs should not be established.

Minimum Egg Weight

The size of the newly hatched chick is directly related to the size of the egg from which it hatches Because egg size increases as the hen continues to produce eggs, there is a marked variation in the size of eggs coming into a hatchery. Most hatcheries set up a minimum egg size for hatching purposes, dependent upon the use to which the chicks are to be put—broiler, Leghorn commercial, breeder, etc. Variations of the minimum will be between 22 and 24 oz per dozen (52 0 to 56 7 gm each)

As customers do not like small chicks, particularly when they are mixed with those of normal or large size, weight of the eggs placed in the incubator may become especially important, as Table. 7 6 shows.

TABLE 7 6

EFFECT OF EGG SIZE ON CHICK SIZE

Egg Weight		Eggs from 8 Month old Hens
Avg/doz Oz	Each Gm	Day old Chick Weight Gm
19 9	45-49	29 3
22 0	50-54	32 3
24 1	55-59	34 6
26 2	60-64	37 7
28 3	65-69	41 1

Source K T Somaiah and H V Shirley, 1963, Tennessee Farm & Home Sci, No 48

From Table 7 6, it may be noted that chick weight varies between 60 and 61% of the weight of the egg from which it is hatched

Preincubation of Hatching Eggs

In some instances hatching eggs are preincubated to increase the percentage of hatchability That is, they are subjected to a temperature of 101°F (38 3°C) for 6 to 8 hours, then cooled to room temperature before being placed in the incuba tors Under some conditions this may have merit, but any increase in hatchability is usually offset by the increased cost of preincubating the eggs

That the incubation process is cumulative and any preincubation at near normal incubating temperatures shortens the regular incubation period by an equivalent time is shown in Table 7 7

TABLE 7 7

EFFECT OF PREINCUBATION TIME ON LENGTH OF REGULAR INCUBATION PERIOD

Hours Held after Laying at 101°F (38 2°C) Before Cooling	Hours of Regular Incubation Period	Total Hours of Incubation	% Hatch of All Eggs Set
0	532	532	80
6	523	529	82
12	519	531	81
18	514	532	56
24	498	522	52

Warming Eggs Prior to Incubation

Hatching eggs should not be removed from the cool holding room and placed directly in the incubators Rather, they should be warmed to room temperature first This process may take from 4 to 6 hours, depending upon the temperature of the room To place cold eggs in the incubator usually reduces the heat within the incubator until the freshly set eggs reach incubating temperature This cool environment delays the hatching time of the newly set eggs and lowers the hatch ability of the eggs already in the machines

Egg Dipping

Under certain conditions, particularly as a part of a PPLO-control program, hatching eggs may be dipped in an antibiotic solution prior to setting In the course of this process eggs are heated, then placed in a cold solution containing the antibiotic Not only does the antibiotic destroy certain organisms on the shell of the eggs, but some of it is drawn through the shell pores and shell membranes as the egg contents shrink in the cold solution Here the antibiotic destroys some organisms

Procedure for dipping eggs The procedure for dipping eggs is as follows

(1) Preheat eggs for 6 hours in a room kept at a temperature of 102°F (39 0°C) Fans should be used for circulating the air in the room The internal temperature of the eggs should rise to about 90°F (32 2°C)

(2) Mix the antibiotic compound with water and place it in a special tank

which will keep the solution refrigerated without any rise in temperature once the warm eggs are placed in it.

Some antibiotic combinations: Antibiotic solutions are combinations of ingredients. *Some are as follows:*

Tylosin tartrate	3,000 ppm
Iodine, or	50 ppm
Quaternary ammonia	50-200 ppm
Tylosin tartrate	3,300 ppm
Erythromycin	1,000 ppm
Iodine	60 ppm
Quaternary ammonia	50 ppm
Tylosin tartrate	3,000 ppm
Neomycin sulphate	1,000-3,000 ppm
Quaternary ammonia	200 ppm

Note: Many mixtures are sold as commercial products.

(3) Cool the solution to 45°F (7.2°C) with a compressor of a size that will prevent the temperature from increasing more than 5°F (2.7°C) after the warm eggs have been in it for 5 minutes.
(4) After 1 batch of eggs is removed, recool the solution for 30 minutes before placing the next batch in it.
(5) After completion of one day's operation, the solution should be filtered, the tank cleaned, and the solution allowed to reenter the tank.

Caution: Egg dipping by this procedure will normally reduce hatchability from 2 to 5%, depending upon the age and size of the eggs and the uniformity of the solution in which they are dipped.

Factors Affecting Hatchability

The actual process of hatching a chick is complicated, and there are a great many factors affecting the normal procedure The environment in which eggs are incubated plays an important part, as do position and turning of the eggs Since the advent of artificial incubation many years ago, optimums for most of these factors have been determined and incubators operate within narrow limits Temperature, humidity, and ventilation in the incubating cabinet are now electrically manipulated to provide the proper conditions for normal embryonic development But there are still problems Some hatches are poor

There is little doubt that hatchability could be improved in most hatcheries Any additional chicks hatched involve practically no cost Often a small percentage of difference in hatchability may mean the difference between profit and loss from the hatchery operation

Percentage Hatchability Defined

Hatchability may be measured by two formulae

(1) The number of chicks hatched as a percentage of *all* eggs set

(2) The number of chicks hatched as a percentage of the *fertile* eggs set

From a commercial standpoint the first definition is popular, but to distinguish variability in the fertility of eggs from hatchability, the second definition is used when scientists examine hatchability data critically

FERTILITY AND SEX

The ability of the female breeder to produce fertile eggs depends on factors in the laying pen Good, viable breeding males and healthy, normal breeding females are a requisite Therefore, fertility is the result of laying house management rather than the outcome of hatchery management The difficulty lies in the fact that most commercial poultrymen talk of hatchability as being the percent of chicks hatched from all eggs set, rather than those from the fertile eggs This leads to incorrect assumptions as Table 8 1 shows

TABLE 8 1

PERCENT TOTAL HATCH WHEN PERCENTAGE OF FERTILE EGGS AND PERCENTAGE OF HATCH OF FERTILE EGGS VARY

% Fertility	% Hatch of Fertile Eggs					
	95	90	85	80	75	70
	% Hatch of All Eggs Set					
95	90 2	85 5	80 8	76 0	71 3	66 5
90	85 5	81 0	76 5	72 0	67 5	63 0
85	80 8	76 5	72 3	68 0	63 8	59 5
80	76 0	72 0	68 0	64 0	60 0	56 0
75	71 3	67 5	63 8	60 0	56 3	52 5
70	66 5	63 0	59 5	56 0	52 5	49 0

Example: With a fertility of 95% and with 75% hatch of fertile eggs, the hatchability of all eggs set is 71.3%. But also when the fertility is 75%, and hatchability of fertile eggs 95%, the hatchability of all eggs set is 71.3%.

From Table 8.1, there are many combinations of fertility and hatchability of fertile eggs that give the same figure for hatchability of all eggs set.

When you study a hatchability problem: Always be sure you separate fertility and hatchability and consider each as a separate entity. First see where the problem lies—in fertility or hatchability.

Determining Infertile Eggs

Eggs may be *candled* to determine which are clear (infertile) and which contain embryos. This is a crude method giving only approximations. If an accurate differentiation between fertility and infertility is desired, incubated eggs should be broken out and examined. With this procedure it may be observed that many embryos have died in the very early stages of development—so early that the eggs appear clear under the candle. Such eggs must be classified as fertile. The problem lies with very early embryonic mortality, even before the egg is laid.

Predetermining Fertility

It would be advantageous to be able to differentiate between fertile and nonfertile eggs prior to incubation, yet no system has been devised to make this classification. Specific gravity, egg shape, air cell, and shell texture are not indicators of fertility. The only acceptable practice is to incubate the eggs for several hours or days, then place them before a bright light (candle) to observe embryos (living or dead), or lack of embryos. Special lighting systems make it possible to complete this technique after only a few hours of incubation. With commercial candlers several days of incubation are required.

Predetermining Sex

There is no method for determining the sex of the living embryo at the time the egg is laid or at any time thereafter until hatching. Shape of eggs, position of the air cell, specific gravity of eggs, or other factors are not correlated with the sex of the developing chick.

Sex Ratio

In all probability the ratio of males to females is nearly equal at the time the ova are fertilized, but variations in mortality during embryonic development usually cause a preponderance of males over females at the time of hatching. Such differences in prehatching mortality are due to:

Genetics: Strains of chickens differ.

Lethals: Some lethal genes are associated with sex, killing more of one sex than another.

Physical factors: Evidently one sex is better able to adjust itself to the environmental conditions of incubation.

Time of egg laying: Sex ratios change according to the egg production period—time of day, time of year, etc.

Correct sex ratio: There is no such figure because of the many factors in-

volved The ratio varies with the strain of chickens, season of the year, time in egg production, size of egg, and other factors

Fertility Inherited

To some extent, fertility is an inherited factor For instance, some strains of poultry produce better fertility than others Furthermore, individual males and females vary in their ability to produce viable embryos Certain mutations are correlated with infertility Homozygosity of the "R" gene for rose comb is associated with poor fertility in males, but not in females In this case it is further known that sperm cells with an "RR" makeup are unable to compete effectively with those of "Rr" composition When each is present those with "Rr" characteristics are responsible for more of the fertilization

Similarly, it is known that fertility in Cornish birds is less than with other breeds, yet when artificial insemination is used, fertility is normal

It is also known that by continuous selection within a strain of chickens over a period of years it is possible to increase or decrease fertility

Improved hatchability indirectly improves fertility Genetic selection, generation after generation, to improve hatchability as defined as the percent hatch of *total* eggs set, has obviously involved both fertility and hatchability, *per se* But the modern geneticist, in developing his poultry lines, will study each separately

INCUBATION TEMPERATURE

The living embryo has an optimum environmental temperature at which it best completes its growth This does not mean that growth will not be initiated at temperatures below the optimum It does mean that when temperatures are below this optimum, growth rate is impaired and the embryo weakened

Physiological Zero

Physiological zero is that temperature below which embryonic growth is arrested and above which it is initiated However, there may be some embryonic development below the physiological zero, though slight This has made it difficult to determine the figure accurately Furthermore, it varies with strains and breeds of chickens Originally, the physiological zero was thought to be 68°F (20°C), but recent research work has established that it is in the neighborhood of 75°F (23 9°C)

Optimum Temperature for Incubation

When incubated in a forced-draft incubator, some chicken eggs will hatch provided the temperature is between 95° and 105°F (35° and 40 5°C) However, there is an optimum temperature, somewhere between the two figures, at which the embryo develops best Research work has shown that the optimum temperature during the first 19 days of incubation is somewhat higher than that required during the last 2 days

Exact optimum temperature differs with incubators The exact optimum will vary with different makes of incubators, and as each manufacturer has accurately established the temperature at which hatchability and chick quality are best, his directions should be followed implicitly

When incubating temperatures deviate from the optimum, hatchability declines and the incidence of malformed chicks increases. The ambient temperature at which the egg is incubated affects the length of the incubation period. As temperature increases above the optimum, the incubation period is shortened; as it decreases, the incubation period is lengthened. This does not mean that it is advisable to raise or lower the temperature from the established optimum. Doing so only weakens the embryos and results in chicks of poor quality.

The optimum incubating temperature is not the same for all eggs. Many factors influence it:

(1) size of the egg;
(2) shell quality;
(3) genetics (including breed and strain of chicken);
(4) age of the egg when it is set;
(5) humidity of the air during incubation.

As eggs vary greatly in items (1) through (4) above, optimum incubating temperatures have been established for "average" eggs. Generally speaking, it is impractical and uneconomical to segregate hatching eggs to take advantage of varying optimum incubating temperatures according to egg modifications.

Three Optimum Temperatures

Embryonic growth may be divided into three phases, each requiring a different temperature.

(1) *Prior to egg laying*

The body temperature of the hen fluctuates between 105° and 107°F (40.6°-41.7°C). As the new embryo completes many cellular divisions during the 20 hours between the time of the union of the sperm and egg cells and the time the egg is laid, the optimum temperature for embryonic development during this period must be that of the body temperature of the hen.

Although some embryonic mortality does occur during this period, it is doubtful if the incidence is due to improper temperature.

(2) *During the first 19 days of incubation*

Although varying according to the make of forced-draft incubator, the optimum temperature lies somewhere near 99.5° to 99.75°F (37.5°-37.7°C).

(3) *During the 20th and 21st days of incubation*

In forced-draft incubators, best hatchability occurs when the temperatures is lowered from that required during the first 19 days to 97° to 99°F (36.1°-37.2°C), depending on the incubator used.

These variations indicate that the developing embryo is quite critical of its environment; and because of the narrow confines in the temperature at which it best develops after artificial incubation begins, all incubators must be capable of having their temperature regulated within small fluctuations.

Variation of Optimum Temperatures

Because optimum incubating temperatures have been developed using "average" eggs, hatchability could obviously be improved if the optimum were known for every type and size of hatching egg, under varying weather and other environ-

mental conditions, and adjustments made in incubating temperatures accordingly But regardless of the manufacturer's recommendations, incubators should undergo some experimentation to determine the exact optimum incubating temperatures under local conditions and with the type of hatching eggs involved Even small corrections will usually show some improvement in either hatchability or chick quality

Resistance to Cooling

Under natural conditions, hens leave the nest many times each day during the incubation period Cooling of eggs during the hen's absence from the nest is evidently not detrimental to hatchability under natural conditions Under artificial incubation, in forced draft incubators, short-term periodic cooling of the hatching eggs also has merit, but the procedure cannot be used economically even though it may improve hatchability as much as 2 or 3% However, there are times when electric failures cause a reduction in the environmental temperature that may last for a short period or for several hours During the first 19 days of incubation, reducing the temperature to as low as 65° F (18 3°C) will not seriously affect the hatching percentage Cooling during the first 2 weeks of incubation is more detrimental than during the next 5 days

Cooling lengthens the incubation period

As incubation is a cumulative process, any reduction in the incubating temperature will increase the length of the incubation process, but by not as much time as the cooling period itself This is because temperatures are seldom reduced below a room temperature of 65° to 70° F (18 3°–21 1°C) Even then the contents of the egg will remain above room temperature for several hours

Cooling increases the incidence of malpositions

Cooling incubating eggs during the first 19 days increases embryonic mal positions The lower the temperature, the higher the incidence

Cooling During 20th and 21st Days of Incubation

Although the embryo can withstand drops in incubating temperature during the first 19 days, disaster generally results when the temperature is lowered during the last 2 days Electric interruptions during this period of incubation, even if only for a short period, are critical

Standby electric equipment necessary No hatchery should be operated unless there is assurance that there will be no cessation of electric current This is an absolute necessity during the hatching period (20–21 days) Consequently, standby electric equipment must be installed to take over when the regular supply falters

If the normal supply of power is relatively good, with interruptions of short duration, the standby generator may be connected only with the hatching compartments, but if interruptions are long and frequent, all incubating equipment should be connected Consult your incubator man ufacturer for the size and type of generator needed

Increased Incubator Temperature When Electric Power Fails

When electric power fails, fans used to distribute heat uniformly in the in cubator stop Hot air rises to the top of the compartment, and eggs in this area

become overheated. This sudden rise in temperature is not relatively important during the first 19 days of incubation, but during the last two days the embryos in the top trays in the hatcher, where the heat is the greatest, suffer drastically. Depending on the stage of incubation, the hatch may be reduced to almost zero. Here again a standby generator is indispensable, and the speed with which it can be placed in operation is just as important.

How to Check Thermometers

All thermometers used in the incubators should be checked for accuracy occasionally. First secure a good test thermometer. Heat a pail of water to approximately 100°F (37.8°C). Place the test thermometer and one or more incubator thermometers in the water and stir to keep the water temperature uniform. While thermometers are still in the water, check recording temperatures against the test thermometer.

Reuniting separated mercury: When the mercury in the thermometer separates, temperature readings are inaccurate. To reunite the mercury:

(1) Place the thermometer in the freezer section of a refrigerator for about 30 minutes. Remove the thermometer and shake the mercury down into the bulb, or

(2) Place the thermometer in water warm enough to force the mercury into the bulb at the top of the tube, being careful not to have the water too hot. Remove and shake the mercury down as it cools.

HUMIDITY DURING INCUBATION

For an embryo to develop properly and to transform into a chick of normal size, the egg contents must evaporate at an established rate. When the egg contents dry out too rapidly the chick will be smaller than normal; when the egg does not evaporate fast enough the chick will be larger. In either case the embryo is weakened, resulting in lowered hatchability and a chick of poor quality. To regulate the evaporation of the egg contents the amount of moisture in the air surrounding the egg must be controlled, as this outside moisture determines the rate of the egg weight loss. High humidity reduces egg evaporation; low humidity increases it.

Definition of Humidity

Warm air is capable of holding more moisture in the form of water vapor than cool air. Thus, air at different temperatures has the capacity to hold different maximum amounts of moisture. But air is seldom saturated, or carrying its maximum amount of moisture, regardless of its temperature. Humidity of the air becomes a "relative" thing, and the amount of moisture in the air compared with what it is capable of holding at that temperature is measured as relative humidity in terms of percent.

Example: If the relative humidity of the air is 40% and the temperature 99°F (32.2°C), it means that the air at that particular temperature contains only 40% of the moisture it is capable of holding.

Measuring Relative Humidity

Relative humidity may be calculated by comparing the temperatures recorded by wet-bulb and dry-bulb thermometers. The dry bulb records the normally

known temperatures of the air. The wet bulb thermometer is an ordinary thermometer in which the bulb has been covered with a water moist wick. When air is forced around this bulb and wick, there is a cooling effect produced by the evaporation, and the more cooling, the lower the recorded wet bulb temperature.

As temperature determines the amount of moisture air will hold at maximum capacity, a table must be used in order to determine the percent relative humidity of the air being measured. Table 8.2 shows this.

TABLE 8.2

PERCENT RELATIVE HUMIDITY AS DETERMINED BY DIFFERENCES IN WET BULB AND DRY BULB THERMOMETER READINGS

Dry bulb Reading		Degrees Wet bulb is below Dry bulb Temperature							
		Degrees Fahrenheit							
		1.8	3.6	5.4	7.2	9.0	10.8	12.6	14.4
		Degrees Centigrade							
		1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
°F	°C	%	%	%	%	%	%	%	%
95.0	35.0	94	87	81	75	69	64	59	54
96.8	36.0	94	87	81	75	70	64	59	54
98.6	37.0	94	87	82	76	70	65	60	55
99.5	37.5	94	88	82	76	71	65	60	55
100.4	38.0	94	88	82	76	71	66	61	56
102.2	39.0	94	88	82	77	71	66	61	57

As the temperature of the air in the incubator is maintained within close limits of 97° to 100°F (36.1°-37.8°C), some hygrometers have been converted to percent relative humidity and read direct at 99.5°F (37.5°C), as shown in Table 8.3.

TABLE 8.3

PERCENT RELATIVE HUMIDITY AS DETERMINED BY WET BULB READING WHEN DRY BULB TEMPERATURE IS 99.5°F (37.5°C)

Wet bulb Reading. Degrees Fahrenheit										
98.6	96.8	95.0	93.2	91.4	89.6	87.8	86.0	84.2	82.4	80.6
Wet bulb Reading. Degrees Centigrade										
37	36	35	34	33	32	31	30	29	28	27
Percent Relative Humidity										
97	91	85	79	73.5	68	62.5	57.5	52.2	47.5	42.5

Importance of Correct Humidity

To insure proper dehydration of the egg contents the relative humidity of the air in the incubator during the first 19 days of incubation must be confined within rather narrow limits. Depending on the make of incubator, these limits are 50 and 60%, but hatchery operators should experiment to determine a precise percentage.

Reducing the humidity of the incubating compartment (1 to 19 days) lengthens the hatching period; increasing it shortens the incubation time. Generally, too much humidity during the first 19 days of incubation will cause the chicks to hatch earlier than normal and they will be larger, and soft in the abdomen. Too little humidity will produce opposite effects, and also dehydrated shanks.

Egg Weight Loss During Incubation

Hatching eggs of average size should lose approximately 10.5% of their weight during the first 19 days of incubation, but there are many factors influencing the figure. Egg size (weight) is the predominant one. The weight loss throughout the 19-day period of incubation is not constant. The loss starts slowly, increases slightly during the second week and part of the third, and then rapidly during the 17th, 18th, and 19th days.

Rule of thumb: Because the exact optimum daily weight loss of incubating hatching eggs is not known, for practical purposes it may be assumed that the weight loss is uniform, and that eggs of average size should lose 0.55% of their weight each day through the 19th day.

How to calculate egg weight loss:

(1) Weigh an empty incubator tray when eggs are set. Fill the tray with eggs of medium weight and weigh the tray and the eggs.
(2) Subtract the weight of the empty tray from the weight of the eggs and tray. This will give the net weight of the eggs.
(3) After several days of incubation weigh the tray and the eggs and subtract the weight of the tray, arriving at the weight of the eggs.
(4) Calculate the egg-weight loss as a percent of the original egg weight.
(5) Check the calculation against a recommended weight loss of 0.55% per day.

Shell Quality and Humidity

Air moves more freely through shells of poor quality than shells of good quality. Thin, chalky, porous shells are instrumental in increasing evaporation of the egg contents, thus producing chicks smaller than normal for the size of the egg involved. Chicks from eggs with thick, dense shells tend to be somewhat larger than normal, because there has not been as much egg evaporation during the incubation process. An indication of these variations in weight loss is shown in Table 8.4.

TABLE 8.4

INFLUENCE OF SHELL QUALITY ON WEIGHT LOSS DURING INCUBATION
(57% Relative Humidity)

Egg Weight Oz/Doz	Egg Weight Gm/Each	Shell Characteristic	Weight Loss, 1–19 Days of Incubation %
24	56.7	Average	10.5
24	56.7	Thin	13.5
24	56.7	Thick	8.0

Egg Size and Humidity

If eggs of average size and average shell quality should lose approximately 10 5% of their weight during the 19-day incubation period, it is obvious that smaller or larger eggs, incubated under identical conditions of temperature and relative humidity, will lose proportionately more or less weight Shown in Table 8 5 is the variation in weight loss according to egg size and the percentage of relative humidity under which they are incubated

TABLE 8 5

RELATIVE HUMIDITY EGG SIZE AND ESTIMATED WEIGHT LOSS

	Weight of Eggs				
	Ounces per Dozen				
	22	24	26	28	30
	Grams Each				
Relative Humidity in Incubator	52 0	56 7	61 4	66 1	70 9
	Loss of Egg Weight 1–19 Days of Incubation				
%	%	%	%	%	%
70–80	9 2	8 8	8 5	8 2	8 1
60–70	10 1	9 6	9 2	9 0	8 8
50–60	11 0	10 5	10 1	9 8	9 6
40–50	12 2	11 6	11 2	10 8	10 6
30–40	13 4	12 8	12 3	11 9	12 9
20–30	15 0	14 3	13 8	13 4	13 1

Just how the relationship between egg weight loss and hatchability operates is not known All eggs do not evaporate at identical rates when held in air of the same relative humidity The differences may be great under certain conditions Thus, loss of the mass is at least not the entire guiding influence There is evidently little if any difference between the weight loss of infertile and fertile eggs, therefore, embryonic development does not seem to be a determining factor

But there is an optimum relative humidity of the air in which each egg will hatch best, and this optimum can be correlated with the weight (mass) of the egg

Egg Size and Weight Loss

The area of the shell (surface) is indirectly related to the weight of the egg contents Large eggs have less shell area in proportion to their weight than small eggs As egg evaporation depends mainly on the area of the shell and the number of pores through which moisture is lost, large eggs lose a smaller percentage of their weight during incubation than small eggs Therefore, egg size is a factor In fact, the differences are great, more than 100% at times Some of these variations are shown in Table 8 5

Considering that all egg weights in Table 8 5 are not included, it is evident that small eggs will lose much more of their weight than extra large eggs when each group is incubated at 50 to 60% relative humidity This wide difference would seem to indicate that some eggs are not being incubated under optimum conditions of relative humidity

Example From Table 8 5, it may be observed that eggs of varying sizes would have to be incubated at the percentages of relative humidity shown in Table 8 6 to lose the same percentage of weight

TABLE 8 6

RELATIVE HUMIDITY AND EGG SIZE

Original Weight of Eggs		Percent Relative Humidity in Incubator to Lose 10 5% of Egg Weight during 19 Days of Incubation
Oz/Doz	Gm/Ea	
22	52 0	55–65
23	54 3	52–62
24	56 7	50–60
25	59 1	47–57
26	61 4	45–55
27	63 8	42–52
28	66 1	40–50

The fact remains that recommendations for correct humidity during the incubation period (1–19 days) are based on eggs of *average* weight Individual optimums for each egg probably are not met, but the limits of correct humidity are so wide that good, or relatively good, hatches are produced But they may not be the best Care should be taken not to set together eggs that vary greatly in weight They are best set in separate incubators with a necessary adjustment made in the incubation compartment

Humidity in the Hatcher

During the last two days of incubation (20–21), at a time when the eggs are in the hatching compartment, the humidity in most machines must be increased This is important at a time when the chicks are pipping and hatching Increasing the humidity prevents the beak of the chick from sticking to the newly pipped shell and allows for a freer movement of the chick's head at the time of pipping

A relative humidity of about 75% seems optimum for most incubators at the time of hatching, however, some operate at lower figures But the humidity should be allowed to increase gradually from the percentage maintained during the first 19 days of incubation The 75% figure should be reached slightly before the height of hatching

Too little moisture at the time of hatching will produce chicks smeared with egg or shell, stuck down and partially dehydrated Too much humidity during this period will cause the chicks to be smeared with egg and the navel will not be properly closed

Relationship Between Humidity and Temperature

There is an interaction between temperature and humidity during the embryonic process Higher temperatures require lower humidities and vice versa However, incubator manufacturers have established the temperature at which their machines hatch best, at least for the "average" egg Therefore adjustments only in humidity are practical

If the humidity is to be raised during the last two days of incubation (20-21), the temperature must be lowered Failure in this respect can produce disastrous results not only in hatchability but in chick quality as well

AIR IN THE INCUBATOR

The main components of air are oxygen (O_2), nitrogen (N_2), carbon dioxide (CO_2) and water vapor (H_2O) The free movement of these through the pores of the shell is important, the developing embryo must have a constant supply of oxygen and exhaust carbon dioxide and moisture

Oxygen in the Air

Approximately 21% of air at sea level is oxygen, and it is impossible to increase the percentage appreciably in incubators unless pure oxygen is introduced

Although the oxygen content of air in a commercial incubator is not often affected, it might be a factor in the hatcher compartment where large amounts of carbon dioxide are being generated by the newly hatched chicks, for it is known that oxygen concentration may be artificially reduced below that encountered under normal conditions In such cases, hatchability drops about 5% for each 1% the oxygen content of the air drops below 21%

Under normal operating conditions incubators have a constant supply of fresh air In most instances the intake far exceeds any necessary amount Consequently, occasions when there would be an inadequate supply of fresh air seem unimportant

Carbon Dioxide in the Air

As the embryo advances in age its oxygen requirement increases and more carbon dioxide is given off Each process is speeded up approximately 100 times between the 1st and 21st day of incubation, as Table 8 7 shows

TABLE 8 7

GASEOUS EXCHANGE DURING INCUBATION
(per 1 000 Eggs)

Day of Incubation	Absorption of Oxygen Cu Ft	Expulsion of Carbon Dioxide Cu Ft
1	0 5	0 29
5	1 17	0 58
10	3 79	1 92
15	22 70	11 50
18	30 00	15 40
21	45 40	23 00

Source A L. Romanoff 1930 *J Morphol.* 50 517 525

On the 18th day of incubation 1,000 eggs would require 143 cu ft (4 1 cum) of fresh air (oxygen in the air at 21%) An incubator holding 40,000 eggs would need 1,720 cu ft (48 9 cum) of fresh air, or approximately 71 cu ft (2 0 cum) per hour This would mean that the air in the incubator would have to be changed about 8 times a day or once every 3 hours Necessarily these are minimums, and although oxygen is critically necessary for the embryonic process the

amount of fresh air needed in an incubator is relatively small. As air intakes in most machines are generally more than adequate, care should be taken to see that overventilation does not become a problem.

Carbon Dioxide Tolerance

Carbon dioxide in the air in incubators is a natural by-product of metabolic processes during embryonic development. Evidently the embryo needs low concentrations of the gas, but exorbitant amounts are detrimental to hatchability. The tolerance has been established at 0.5%, and hatchability is reduced proportionately to any increases in this amount. Concentrations above 1.5 to 2.0% usually result in drastic reductions in hatchability.

Speed of Air Flow

There is little evidence to show that variations in the velocity of air flowing past the eggs in an incubator have any effect on hatchability. The important factor seems to be the ability to maintain enough air movement to provide a uniform temperature throughout the incubating cabinet. Many innovations in devices to circulate the air in incubators have been perfected; paddles, blades, and fans are used, each creating an air flow, or movement, from very slow to rapid.

Deduction: As long as the hatchability of eggs incubated in all sections of the incubator is uniform, one may surmise that air flow is adequate. If nonuniformity occurs, anemometers should be employed to test the speed of air in all sections of the machine.

POSITION OF THE EGG DURING INCUBATION

It is necessary that the egg be kept in the proper position during incubation, and turned regularly.

Even under natural conditions eggs do not lie flat in the nest of the hen; the large ends come to the top. Eggs under artificial incubation should be held with their large ends uppermost, but this does not necessarily mean in a vertical position. However, eggs should not be set with the small end up. It is the natural procedure for the head of the chick to develop in the large end of the egg near the air cell and for the developing embryo to orient itself so that the head is uppermost. Most of this rotation occurs during the second week of incubation and is most easily completed when the large end of the egg is kept higher than the small end. When eggs are incubated with the small end up, about 60% of the embryos will develop with the head near the small end. Thus, when the chick is ready to hatch, its beak cannot break into the air cell when pulmonary respiration starts, and hatchability is reduced.

Turning Eggs During Incubation

During incubation (1–19 days) chicken eggs should be turned or rotated. Under natural incubation the hen turns the eggs many times a day. With artificial incubation eggs are usually rotated back and forth along their long axes to produce the turning process. Eggs should not be turned in a circle, as this ruptures the allantoic sac with resultant mortality. For greatest hatchability eggs should be turned to a position 45° from the vertical, then reversed in the opposite direction to a similar position. Less rotation is not adequate for high hatchability, as Table 8.8 indicates.

TABLE 8.8

EFFECT OF ANGLE OF TURNING EGGS DURING INCUBATION

Angle Turned to Each Side of Vertical	Percent Hatch of Fertile Eggs
20°	69 3
30°	78 9
45°	84 6

Note Eggs should be turned only during the first 19 days of incubation They are then transferred to the hatching compartment and allowed to remain stationary while the chicks are hatching

Speed of Turning

During the first 19 days that eggs are under incubation they must be turned periodically Table 8 9 shows the percentage hatchability of eggs turned from two to ten times a day

TABLE 8.9

THE EFFECT OF TURNING EGGS ON HATCHABILITY

Times Turned Daily	Percent Hatch of Fertile Eggs
2	68 2
4	71 3
6	74 6
8	74 8
10	74 7

Although other experiments have shown that turning eggs as often as every 15 minutes is not detrimental to hatchability, little is to be gained by turning more than six to eight times a day when the eggs are rotated back and forth along their long axes

Important When eggs are turned the process should be completed quickly, then the eggs allowed to remain stationary and resting until the next turning Hatchability is lowered when eggs are kept in a constant back and forth motion

Transferring Eggs to Hatcher

With modern incubators eggs are transferred from the incubating compartment to the hatching compartment (hatcher) at the end of 19 days of incubation For convenience, the transfer may be made up to a few hours earlier

Avoid Transferring eggs too early or too late Difficulties arise when eggs from egg type and meat-type breeders are set at the same time in the same machine, as eggs from breeds such as Leghorns have a shorter incuba tion period than those from heavy breeds

What's involved Eggs should be transferred to the hatcher when approxi mately 1% of the eggs are slightly pipped

When to transfer: Several factors affect the length of the incubation period—breed, age of eggs, size of eggs, shell quality, and other factors. Eggs with shorter incubation periods should be set later than those requiring long periods of incubation. When the procedure is correct, all chicks should hatch at the same time.

Another suggestion: If eggs from Leghorns and meat-type birds are to be set in the same machine, the Leghorn eggs should be set so they hatch last. A Leghorn chick from a 24-oz/dozen (56.7 gm/each) egg will dehydrate faster after hatching than one from a 24-oz, meat-type egg. Hatching Leghorn chicks last will shorten the period from hatchery to farm.

Position of Eggs During Hatching

Most commercial incubators provide for keeping the eggs in a horizontal position during the last two days of incubation in the hatcher compartment. Although they will hatch as well if kept upright with the large end up, this method does not seem practical because of the space needed by the chicks in the trays, once they liberate themselves from the shell. There is no evidence to show that changing the position of the eggs at the time they are transferred to the hatchers is detrimental to hatchability.

OTHER FACTORS AFFECTING HATCHABILITY

Atmospheric Altitude and Hatchability

In 1944, the author reported that eggs incubated at an altitude of 7,200 ft (2,195 m) produced a greatly reduced number of chicks compared with similar eggs incubated at an altitude of 700 ft (213 m). This warrants some discussion, as many hatcheries around the world are located at high elevations.

Air varies in its density according to elevation; the higher the altitude, the less dense it becomes. Because air weighs less at higher altitudes it exerts less barometric pressure. When air expands, as at higher altitudes, a cubic volume contains less oxygen. Figures are shown in Table 8.10.

Research has shown that hatchability of chicken eggs is reduced as the altitude at which they are incubated is increased. However, for altitudes under 2,500 ft

TABLE 8.10

RELATIONSHIP BETWEEN ALTITUDE, OXYGEN CONTENT OF AIR, AND BAROMETRIC PRESSURE

Altitude above Sea Level Ft	M	Barometric Pressure In. of Hg	Reduced Weight of Air (or Oxygen) %
0	0	29.92	0
2,000	609	27.82	5.1
4,000	1,217	25.84	11.2
6,000	1,829	23.98	16.4
8,000	2,438	22.22	21.4
10,000	3,048	20.58	26.2
12,000	3,658	19.03	30.7

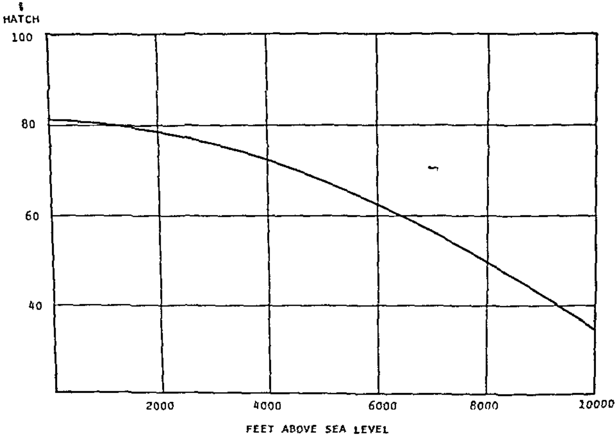

FIG 8 1 RELATIONSHIP BETWEEN ALTITUDE AND HATCHABILITY

(762 m), the reduction is so slight as to be seldom noticed But when the altitude is over 3,500 ft (1,067 m), the loss in hatchability becomes an acute economic problem Fig 8 1 shows the reduction in hatchability at increasing altitudes based on a hatchability of 80% at sea level

Stephens and Pfoog in Peru (3,500 ft (1,067 m) altitude) built a pressure chamber in which they placed a commercial incubator By simulating various altitudes by pressurizing the chamber, they were able to produce hatching results quite comparable to those under natural elevations Pressurizing to sea level restored normal hatchability, this indicates at least one method, though probably not economical, of overcoming the ill effects of high altitude incubation

Another, and more practical method, has been the injection of oxygen directly into the incubator in which the eggs are being incubated Wilgus, H S and W Sadler, 1954, (*Poultry Sci* 33, 460), among others, showed that concentrations of oxygen at 23 to 23 5% increased hatchability materially, compared with the concentration at their elevation of 5,000 ft (1,524 m) They also showed that hatchability at high elevations was quite sensitive to carbon dioxide concentrations between 0 2 and 1 5%

How to inject oxygen Oxygen is introduced into both the incubating and hatching compartments by a tube from oxygen cylinders that have a pressure regulator valve and flow meter A gas analysis apparatus is used to determine the percentage of oxygen in the mixed air within the incubator cabinets Readings must be taken several times a day to maintain the required ratio of oxygen

An interesting fact associated with high altitude incubation is that the lack of xygen alone may not be the contributing factor. Although some scientists feel is a lack of oxygen, others indicate that the amount of carbon dioxide in the ncubating air is important, while still others associate at least a part of the difference to air speed and humidity in the incubator. Many feel it is a lack of *ressurized* oxygen.

Other factors involved with high altitude incubation: Of importance are other factors involved with the practical aspect of high altitude incubation and maintaining breeding flocks.

(1) Strains of chicken vary in their ability to hatch at higher elevations.
(2) Hatching time is increased as the elevation increases, evidently due to a decrease in the carbon dioxide content of the air rather than the change in the oxygen content.
(3) Eggs produced by breeder hens kept at high altitudes seem to produce normal hatches if they are incubated at low altitudes.

Practical application: This means that breeder flocks may be kept at high altitudes as long as the eggs are incubated at low elevations.

(4) Altitude has no effect on the fertility of the eggs produced by the breeder flock.
(5) If one rears the chicks produced from eggs laid by breeder hens kept at high altitudes and the eggs incubated at high altitudes, the mortality of the growing chicks is higher than normal.
(6) Some of the hatchability may be restored if genetic selection is practiced in the breeding program; but Smith and Abbott, attacking this problem, could not restore it to normal after six generations of experimental breeding at high altitudes.

Embryonic Mortality Pattern

Mortality among developing embryos is not uniform throughout the incubation period. There are two peaks:

(1) During second, third and fourth days of incubation.
(2) During 19th, 20th and 21st days of incubation.

Under normal circumstances, twice as many embryos die during the second period as during the first. It is during the first period that the blood system develops; during the second period, pulmonary respiration, pipping, and hatching take place. Both periods are critical to the developing embryo.

How to analyze the problem of excessive embryonic mortality: When there are difficulties in attaining maximum hatches and it becomes necessary to make an analysis of the incubation process, mortality during the two critical periods should be calculated. If the relative percentages are different from those given above, with the first critical period being about half the second, there may be some indication of the cause, as follows:

Mortality during first critical period: Generally can be traced to the breeding flock.

Mortality during the second critical period: Is more apt to be due to faulty incubation procedures.

Position of Embryo in the Egg

Normally, the chick embryo develops with the head in the large end of the egg (near the air cell) and with its head under its right wing But there are many embryos that do not develop in this position These are called "malpositions," and many have been classified and described The more common ones are

(1) Head in large end of egg
- (a) Head under left wing
- (b) Head between legs
- (c) Feet over head

(2) Head in small end of egg
- (a) Head under left wing
- (b) Head between legs
- (c) Feet over head
- (d) Head not under wing

Some chicks in many of the above malpositions will hatch, some will not Certain incubation practices will affect the incidence of malpositions Of all embryos at maturity (18 days) approximately 1 to 4% will be malpositioned An examination of the "dead in-shell" will be necessary to determine the percentage of malpositions and the type involved

Non normal Embryos

There are many embryos that develop other than normal A partial list of these variations is as follows

small head	short beak	curled toes
popeye	crooked neck	wingless
one eye	twisted spine	clubbed down
parrot beak	thickened hocks	dwarf
crossed beak	extra leg	unabsorbed yolk

A normal number of malposition and deformities are probably due to genetic factors not eliminated from the strain, but excessive numbers can be the result of deficient rations fed the breeder parents, faulty handling of eggs, and incorrect incubation practices In a critical examination of reasons for poor hatchability their incidence should be closely established

Artificial Light During Incubation

Tammie and Fox reported an interesting but unconfirmed finding that eggs having continuous exposure to artificial light during the incubation process produced fewer chicks, the hatching period was lengthened and the incidence of embryonic malformities increased

DISEASES ASSOCIATED WITH HATCHABILITY

Several poultry diseases which affect the parent breeder flocks are associated with hatchability, some establish themselves in the hatchery and incubators through retention of the organisms responsible for the disease Although they are discussed in detail in later chapters, the important ones are

Omphalitis (mushy chick disease)
Pullorum (caused by *Salmonella pullorum*)

Typhoid and paratyphoid (*Salmonella* infections)
Mycoplasma (*M. gallisepticum* and *M. synoviae*)

Each of the above has an effect on hatchability, chick quality and livability of the chick after it hatches. When any of these are in evidence, there has been a failure in the breeding flock, with egg transmission of the causitive organism, or unsanitary conditions in the hatcher, so that the disease-producing organisms were not destroyed.

Fumigation of Hatching Eggs During Incubation

Many organisms locate on the eggshell, in the incubator room, or in the incubator itself. Formaldehyde gas fumigation will aid in the destruction of many of these, but not all. Bacteria are the ones most easily killed.

Note: See Chapter 9 for details of fumigation.

Preincubation Heat Treatment to Inactivate Mycoplasma

A method of killing Mycoplasma organisms in eggs prior to incubation has been detailed by H. W. Yoder, Jr. of the Southeast Poultry Research Laboratory, USDA, Athens, Georgia (*Avian Diseases*, Feb. 1970). Specifically for the control of *M. synoviae*, inasmuch as there is a recognized and practical method of eradicating *M. gallisepticum* through elimination at the breeder level, this method is described because of its practicability in preventing egg transmission of *M. synoviae.*

Procedure for heat treatment: Briefly the method is this:

(1) Hatching eggs are removed from the cool, holding room to a room with a temperature of about 72° F (22.2° C) and held there until eggs reach the same temperature.

(2) Hatching eggs are then placed in another compartment or room having a temperature slightly higher than 115° F (46.1°C).

Caution: This area must have uniform heat. It is critical. Moderate, but adequate, forced-air circulation is a must. Do not use a thermostat to control the room temperature, for it will kick off the heat supply at temperatures below 115° F (46.1°C). The relative humidity of this room must be about 70%.

(3) Eggs are kept in this room (2) for approximately 10 to 14 hours.

Important criterion: The center of the egg must reach 115° F (46.1°C) and no higher. The time to accomplish this will vary according to the temperature of the eggs when heating starts, humidity of heated air, and size of the eggs. When the desired temperature is reached, the heating process must continue for about two hours; it is then stopped, and the eggs placed under incubation. Do not try to heat the eggs quicker than 10 hours. Such a procedure will not kill the Mycoplasma organisms.

Thermometer needed: It is necessary that the interior temperature of the egg be accurately determined. This can only be done with a thermocouple, a precision instrument for determining internal temperatures, or by a thermometer with the bulb inserted in the egg. Seal the shell at point where thermometer enters the shell.

Another method Place the bulb of a thermometer in a glass of sand This should give the same reading as the interior of the egg

Heat lethal at 117°F (47 2°C) The object of the heat treatment is to kill the Mycoplasma organisms without damaging the embryo any more than necessary The temperature inside the egg should not be allowed to go over 115°F (46 1°C) A temperature of 117°F (47 2°C) borders on the lethal area, and hatchability will be reduced to half that incurred during recommended treatment

(4) After treatment, eggs must be cooled quickly, as follows

Cool the center of the eggs to room temperature, then place them in the incubator

Effects of heat treatment on incubation Obviously, the method of egg heating borders on the critical, and two important changes result during later regular incubation

(1) Hatchability will drop 2 to 5%
(2) Incubation period will be lengthened by five to six hours

Note Although preincubation of hatching eggs at a temperature of 100° to 101°F (37 8°–38 3°C) will shorten the normal incubation period, a temperature of 115°F (46 1°C) will weaken the embryo and hatching time will be delayed Allow *the chicks ample time to dry off*

Heat treatment and its effect on resultant chicks This procedure evidently does not affect the quality of the hatched chicks, or increase the mortality encountered during the growing period In fact, mortality is usually less

ANALYZING POOR HATCHABILITY

Observation	May be caused by
Clear eggs	Infertile Very early mortality
Bloodring (embryonic death 2–4 days)	Diseased breeding flock Incubating temperature too high Incubating temperature too low Old eggs
Dead embryos 2nd week of incubation	Temperature too high Temperature too low Egg not turned Inadequate breeder ration Too much CO_2 in air (not enough ventilation) Eggs not cooled prior to incubation
Hatch late	Temperature too low, 1–19 days Humidity too low, 1–19 days Incorrect thermometer Large eggs Old eggs Temperature too low in hatcher Variable room temperature

Observation	May be caused by
Hatch early	Temperature too high, 1–19 days Incorrect thermometer Small eggs Humidity too high, 1–19 days Leghorn eggs vs meat type eggs
Air cell too small	Humidity too high, 1–19 days Inadequate breeder ration Large eggs
Air cell too large	Humidity too low, 1–19 days Small eggs
Fully developed embryo dead with beak not in air cell	Temperature too high, 19th day Humidity too high, 19th day Inadequate breeder ration
Fully developed embryo dead with beak in air cell	Temperature too high, 20–21 days Humidity too high, 20–21 days Inadequate breeder ration Incubator air circulation poor
Chicks pipping early	Temperature too high, 1–19 days
Chicks dead after pipping shell	Temperature too high, 20–21 days Inadequate breeder ration Inadequate air circulation, 20–21 days Incorrect temperature, 1–19 days Temperature too low immediately after egg transfer is made to hatcher
Chicks dead after pipping shell	CO_2 content of air is too high, 20–21 days Thin shelled eggs Disease in breeding flock
Trays not uniform in hatch or chick quality	Inadequate incubator air circulation Eggs of different sizes Eggs of different breeds Eggs of different age when set Disease or stress in some breeder flocks
Sticky chicks (shell, down sticking to chicks)	Humidity too low, 20–21 days Temperature too high, 20–21 days Down collections not adequate Eggs transferred too late
Sticky chicks (albumen sticking to chick down)	Temperature too low, 20–21 days Inadequate air in hatcher Air speed too slow, 20–21 days Humidity too high, 20–21 days Old eggs
Chicks too large	Large eggs Humidity too high, 1–19 days
Chicks too small	Small eggs Humidity too low, 1–19 days Thin, porous shells Eggs produced in hot weather
Crippled chicks	Variation in temperature, 1–21 days

Observation	May be caused by
Mushy chicks	Unsanitary incubator conditions
Unhealed navel, dry	Humidity too high, 20-21 days Temperature too low, 20-21 days Inadequate breeder ration Humidity not lowered after hatching completed
Chicks cannot stand	Improper temperature, 1-21 days Humidity too high, 1-19 days Breeder ration inadequate
Unhealed navel, wet and odorous (mushy chicks)	Omphalitis Unsanitary hatchery and incubators
Soft chicks (abdomen)	Humidity too high, 1-19 days Temperature too low, 1-19 days
Closed eyes	Loose down in hatcher Down collectors not adequate Temperature too high, 20-21 days Humidity too low, 20-21 days
Chicks dehydrated	Humidity too low, 20-21 days Eggs set too early Chicks left in hatcher too long after hatch complete
Malpositions	Continuous light in incubators Inadequate breeder ration

Operating the Hatchery

The operation of a chick hatchery involves the production of the largest number of quality chicks possible from the hatching eggs received at the hatchery. But in addition to this, chicks must be produced economically. Ever-increasing competition and integration within the industry have made hatchery operation a business of small unit margins, and managers must be ever-cognizant of the importance of the little things that produce top profits.

Hatchery management will depend a great deal on the classification of the hatchery involved as determined by the type of chick hatched.

These classifications are:

(1) commercial broiler chick hatchery;
(2) commercial egg-type pullet chick hatchery;
(3) breeder-type chick hatchery;
(4) pedigree chick hatchery.

Other factors that will involve hatchery management are:

(1) integration;
(2) source of supply of the hatching eggs;
(3) number of breeds to be hatched;
(4) chick sexing and other services;
(5) to whom and how the chicks are to be delivered.

SECURING HATCHING EGGS

In past years a great number of hatching eggs were purchased by the hatchery, either directly from the flockowner, or from egg brokers or hatching egg dealers. Nowadays, however, the source of supply is vastly different. Most hatcherymen have their own flocks of breeder chickens, or at least their own guaranteed source of hatching eggs. But there are still many variations in the source of supply.

Source of Eggs

1. *Hatchery owns the breeder hens*
   The breeders may be on hatchery-owned farms, or on farms owned by the flockowner who has entered into an agreement with the hatchery to produce hatching eggs on contract. In the latter case the hatchery actually owns the breeders; the flockowner is paid a contracted amount to produce the eggs. See Chapter 10.
2. *Hatchery secures eggs from flockowners*
   In many sections of the world flockowners exist who actually own both the breeders and the poultry farm. Although most are involved with some type of contract to produce eggs for a hatchery in predetermined quantities, the hatchery does not own the birds. In many cases, however, the hatchery is involved in financing flockowners; that is, the hatchery may lend money to help finance the poultry breeder operation, and the flockowner agrees to pay off his debt by having the hatchery make weekly deductions from his egg payments.

3 *Other hatcheries supply eggs*
On occasion one hatchery may have an oversupply of hatching eggs while another does not have enough Under these circumstances the hatchery with the surplus will sell eggs to the other Such a procedure is quite common with large integrators where one person or company may own and operate several hatcheries

4 *Hatching egg producing companies are sources of eggs*
In certain countries there is still another method of securing hatching eggs Eggs are produced by an egg-operating company which has a large number of poultrymen under contract to produce hatching eggs for it These egg-operating companies, in turn, have an agreement to sell a given number of hatching eggs each week to unattached hatcheries that are directly involved with chick hatching In many instances the eggs may be shipped to a hatchery in another country

Egg Delivery to Hatchery

Hatching eggs usually arrive at the hatchery by truck, although they may arrive at some point in the general locality by rail or air As many hatcheries are on a program of producing MG negative or MS negative chicks, care must be taken to prevent the entrance of these disease producing organisms into the hatchery In these cases, the hatching eggs received would be negative, and they must not be contaminated The following rules must be rigidly observed

(1) Truck drivers and their helpers must shower and change into clean clothes, headgear, and footwear before entering any trucks involved with the egg transport, or before entering the hatchery
(2) All trucks must be disinfected and fumigated with *formaldehyde gas* before eggs are placed in them
(3) Only eggs that are MG negative or MS negative may be placed in the truck

Egg Delivery Record

A system of identifying hatching egg receipts must be established This not only offers a record for the flockowner or trucker, but is of value to the hatchery manager and the hatchery bookkeeping department

The delivery record should include

(1) source of eggs (flockowner, trucker, etc),
(2) date eggs are received,
(3) house, pen, or flock numbers,
(4) breed or line of chickens involved,
(5) number of cases or number of dozens of eggs received

In some cases there may be blank lines on the form for use after the eggs are graded and hatched These are to be used for inserting the following data

(1) number of eggs graded out,
(2) net number of eggs set,
(3) contract or other price per dozen (or unit),
(4) amount paid,
(5) chicks hatched,
(6) percent hatchability

HATCHERY SANITATION

Sanitation in the hatchery manifests itself in the production of higher hatchability and improved chick quality. And chick quality means chicks that not only appear healthy at the time they are hatched, but are free of many disease-producing organisms that may produce their effects later in the life of the chick. It is this latter phase that has brought about the greatest change in hatchery procedure during the past few years. Hatching eggs must be produced by healthy breeding stock, and chicks must be packed in clean boxes, delivered by clean personnel, and in clean trucks.

Disinfectants

Disinfectants are most effective in the absence of foreign organic matter. Disinfecting is not a substitute for cleanliness. It is a means of destroying microorganisms, but only when things are relatively clean to start with.

Disinfectant specifications: All disinfectants used in hatchery sanitation should be

(1) highly germicidal;
(2) nontoxic to man and animals;
(3) effective in the presence of moderate amounts of organic material;
(4) noncorroding and nonstaining;
(5) soluble in water;
(6) capable of penetrating materials and crevices;
(7) unassociated with pungent odors;
(8) readily available and inexpensive

Common basic chemicals used for hatchery disinfecting

Phenol Derivatives:
- cresols
- hexylresorcinol
- hexachlorophene
- orthophenylphenol

Iodine: Composed of iodine compounds (iodophors).

Chlorine: Consisting of chlorine-containing compounds such as:
- hypochlorites
- chloramines

Quaternary ammonium compounds:
- cetylpyridinium chloride
- benzalkonium chloride
- and others

Formaldehyde:
- formalin
- paraformaldehyde
- and others

Properties of Disinfectants

Disinfectants vary in their ability to kill organisms, and in other factors. Table 9.1 shows this variability. The code for this table and Table 9.2 is as follows:

\+ Positive property (+ indicates degree of affinity)
\- Negative property
± Limited activity

Table 9.1 shows that all the disinfectants listed are bactericidal, but not necessarily bacteriostatic However, their ability to destroy fungi and viruses is quite variable

TABLE 9 1

PROPERTIES OF DISINFECTANTS

Property	Chlorine	Iodine	Phenol	Quaternary Ammonium Compounds	Formaldehyde
Bactericidal	+	+	+	+	+
Bacteriostatic	-	-	+	+	+
Fungicidal	-	+	+	±	+
Virucidal	±	+	+	±	+
Toxicity	+	-	+	+	+
Activity with organic matter	++++	++	+	+++	+

Source Canadian Dept Agr., Hatchery Sanitation, 1970

The presence of organic material is a deterrent to good disinfection, and the ability of a disinfectant to be functional varies greatly in this respect Formaldehyde gas and phenols have a lower affinity for organic material, thus their disinfecting powers are greater.

Where Disinfectants May be Used in the Hatchery

Because of their action, certain disinfectants are not practical for some hatchery operations Table 9 2 gives the use to which the various disinfectants may be put

TABLE 9 2

HATCHERY USE OF DISINFECTANTS

Use area	Chlorine	Iodine	Phenol	Quaternary Ammonium Compounds	Formaldehyde
Hatchery equipment	+	+	+	+	+
Water disinfection	+	+	-	+	-
Personnel	+	+	-	+	-
Egg washing	+	-	-	+	+
Floor	-	-	+	+	+
Footbaths	-	-	+	+	-
Rooms	±	+	±	+	+

Source Canadian Dept Agr., Hatchery Sanitation 1970

FORMALDEHYDE FUMIGATION

Formaldehyde is a gas, commercially available as a 40% solution in water (37% by weight) (HCHO) known as formalin, and as a powder, paraformaldehyde, containing 91% formaldehyde When formalin is volatilized, or paraformaldehyde is

heated (and volatilized), formaldehyde gas is evolved. It is quite toxic, with an official tolerance of 5 ppm in air; inhalation should be avoided. The skin is very sensitive to formalin, and there should be no direct contact.

Directions for Use of Formalin

The liberation of formaldehyde gas from formalin is increased in the presence of potassium permanganate. Use an enamelware or earthenware vessel of large capacity, necessary because of the boiling, foaming action when mixed with permanganate. Do not use vessels that will crack. Place the vessel in the area to be fumigated and add the potassium permanganate; then add the formalin.

Caution: Never add the permanganate to the formalin. Heat is generated when the two chemicals are combined, and care should be taken. Formaldehyde gas is generated quickly; do not allow the fumes to get into the eyes.

Allow the fumigation to continue for from 10 to 30 minutes, depending on the type of area fumigated.

Formaldehyde Fumigation Concentration

The amount of formaldehyde gas liberated in a given space determines the concentration. The normal, or single strength, is the result of mixing 40 cubic centimeters (1.35 fluid oz) of formalin with 20 gm (0.71 oz) of potassium permanganate for each 100 cu ft (2.83 cu m) of space. This is sometimes known as 1X concentration. Other concentrations are 2X (twice the above amounts), and 3X (thrice the above amounts). Table 9.4 shows various concentrations, and where each should be used in hatchery fumigation.

Directions for Use of Paraformaldehyde

Paraformaldehyde, a powder, should be placed in an electric generator (skillet or pan) with the thermostatic control set at 450°F (232°C). Allow the gas to liberate for 10 to 30 minutes according to Table 9.4. One pound (454 gm) of paraformaldehyde in a skillet will release its formaldehyde in 20 minutes.

Important: An electric switch to turn off the generator should be on the outside of the compartment or room, as it is usually impossible to get into the area during fumigation.

Temperature and Humidity for Maximum Formaldehyde Disinfection

The efficacy of formaldehyde gas is increased in the presence of heat and moisture. It is impossible to get maximum results unless the temperature of the area to be fumigated is 75°F (23.9°C), or higher, and relative humidity is 75% or more. At lower room temperature and relative humidity, formaldehyde gas is not an effective fumigant.

Neutralizing Formaldehyde Gas with Ammonium Hydroxide

In certain instances it is necessary to stop the action of formaldehyde gas after the required period of fumigation. Usually this may be accomplished by opening the air intakes in the incubators or rooms, but often this method is too slow. Ammonium hydroxide may be used to expedite the process. A solution of 26 to 29% of ammonia should be used. Check to see how much formalin was used,

then sprinkle this same amount of ammonium hydroxide on the floor of the area fumigated The ammonium hydroxide will neutralize the formaldehyde

Recommendations for Formaldehyde Fumigation

Two parts (by volume) of formalin are mixed with approximately one part (by weight) of potassium permanganate This will produce complete expulsion of the gas When the reaction is complete, a dry, brown powder will be left If the residue is wet, not enough potassium permanganate was used, if the residue is purple, too much potassium permanganate was added

Table 9 3 gives the amount of formalin and potassium permanganate needed for each 100 cu ft (2 83 cu m) of space, along with the amount of paraformaldehyde needed to produce a comparable amount of gas

TABLE 9 3

FUMIGATION LEVELS PER 100 CU FT (2 83 CU M)

	To Produce Formaldehyde Gas (Mix Together)				To Produce Equivalent Amount of Formaldehyde Gas	
	Formalin		Potassium Permanganate		Paraformaldehyde Powder	
Strength	Cc	Fluid Oz	Gm	Oz	Gm	Oz
Single (1X)	40	1 35	20	0 71	10	0 36
Double (2X)	80	2 71	40	1 41	20	0 71
Triple (3X)	120	4 06	60	2 12	30	1 06
(5X)	200	6 76	100	3 53	50	1 77

Strength of Formaldehyde Fumigation

Varying concentrations of formaldehyde gas are needed under different conditions In some instances the gas is lethal to disease organisms, but is also detrimental to the embryo Under such circumstances the lowest effective concentration must be used Furthermore, the length of the period of fumigation also is a factor, the longer the period, the greater the effectiveness from a disinfecting standpoint, but also the more critical from an embryological and chick standpoint

Table 9 4 shows the recommendations for formaldehyde fumigation under varying conditions

Special Directions for Fumigation

Fumigation of eggs soon after laying Fumigating with 3X concentration for 20 minutes will kill about 97 5 to 99 5% of the organisms on the shells of brown eggs, and about 95 to 98 5% of those on white eggs, the difference probably being due to the fact that brown eggs have a thicker cuticle which absorbs more gas

As the population of organisms on the shells of eggs is greater in the summer than in the winter, the destruction by the gas will vary A higher percentage will be killed in the summer However, the types or organisms are different during the two seasons

TABLE 9.4

FORMALDEHYDE FUMIGATION CONCENTRATION RECOMMENDATIONS

Fumigation of	Concentration of Fumigant	Time to Fumigate (Minutes)	Neutralizer (Ammonium Hydroxide)
Hatching eggs immediately after they are laid	3X	20	No
Eggs in incubators (1st day only)	2X	20	No
Chicks in hatchers	1X	3	Yes
Incubator room	1X, 2X	30	No
Hatcher, between hatches	3X	30	No
Hatcher room, chick room, between hatches	3X	30	No
Washroom	3X	30	No
Chick boxes, pads	3X	30	No
Trucks	5X	20	Yes

Fumigation of the incubators: Formaldehyde gas is toxic to developing embryos, particularly during the period between 24 and 96 hours of age, a critical period in the life of the embryo. To prevent embryos from being weakened during this critical period, eggs should be fumigated only as soon as they are placed in the machines. They should be fumigated at 2X strength for 20 minutes. Normally, this fumigation is the only one necessary before the eggs are transferred to the hatcher.

Fumigating chicks: Fumigation of chicks is not recommended. However, with omphalitis outbreaks in the hatchery it may be necessary in order to get the disease under control. Formaldehyde fumigation colors the down of the chicks a deep orange, often noticeable by the customer. Chick fumigation should be considered an emergency measure only.

Fumigation between hatches: After the chicks have been removed from the hatchers, and the trays washed, the hatchers, trays, hatcher room, and wash room should be fumigated with formaldehyde gas at the concentrations given in Table 9.4.

Fumigating chick trucks: Because it is difficult to raise the temperature and humidity in the chick truck at the time of fumigation, concentration of the formaldehyde gas should be increased to 5X. Thoroughly clean the chick truck first. It may be advisable to construct a tent that will quickly cover the truck and the chassis. Fumigation can then be completed inside the tent, disinfecting the complete van.

CONTINUOUS SANITIZING IN THE HATCHERY

A new method of hatchery sanitizing known as continuous sanitizing is now in process of investigation. The procedure embodies the injection of certain sanitizing agents into the air ventilation ducts so that they are disseminated continuously to various hatchery rooms. Chlorine-containing or iodine-containing products are used as the sanitizing agents. Early research work indicates that the sanitizers vary in their ability to control certain disease-producing organisms;

some are more effective for coliforms, some reduce the incidence of certain other bacteria

Chlorine injections into the air ducts present a unique method of accomplishing hatchery sanitation Iodine products act similarly, however, they do have the dis advantage of staining the materials with which they come in contact At low levels there is little discoloration, but the sanitizing effect may be limited

HATCHERY DISEASE-CONTROL PROGRAMS

There are several disease control programs that are a part of the hatchery opera tion These call for special procedures, some of which are quite complicated, but must be followed

Salmonella Pullorum Program

Pullorum is an egg transmitted disease Although there is a definite program of eliminating carrier birds from the breeder flocks producing hatching eggs, it does not mean that management in the hatchery can become lax Certain sanitary pre cautions must be followed

(1) Follow the formaldehyde fumigation program explicitly
(2) Purchase only eggs produced by pullorum free breeder flocks
(3) Set only pullorum free eggs in the hatchery
(4) Employees should shower and change into clean clothing before enter ing the hatchery
(5) Keep other than approved personnel out of the hatchery

Remember There are other Salmonella organisms that affect the chicken in a way similar to pullorum Typhoid and paratyphoid organisms are ex amples Sanitation rules in the hatchery are identical, regardless of the type of Salmonella being regulated

Mycoplasma Gallisepticum, S-6 Negative Program

M gallisepticum is the organism responsible for PPLO, a respiratory disease af fecting the air sacs of the chicken The hatchery is involved with certain aspects of a program to eliminate the disease in newly hatched chicks *M gallisepticum* organisms are egg transmitted, and this route is the usual avenue for transmission from adult birds to day-old chicks

The presently accepted method for the control of *M gallisepticum* is by elimi nation, that is, elimination from the breeding flocks by testing individual birds by the serum agglutination method, and by carrying out a sanitation program that will not permit reinfestation of hatching eggs or the newly hatched chicks See Chapter 41 The hatchery phase of this sanitation program should encompass the following

(1) Secure *M gallisepticum*, S 6 negative hatching eggs only
(2) Hatch only *M gallisepticum*, S-6 negative eggs in the hatchery
(3) Use only new, clean chick boxes and chick box pads
(4) All personnel must shower and change to clean clothing, including foot wear and caps, prior to entering the hatchery
(5) Follow the formaldehyde gas fumigation procedure as outlined This in cludes the fumigation of all service equipment as racks, dollies, etc

(6) Have only one entrance and exit to the hatchery. Keep all other doors locked.
(7) Place a large, deep disinfecting footpan and scrub brush inside the entry door.
(8) Disinfect and fumigate chick delivery trucks before loading them with chicks.
(9) Use an incinerator to dispose of hatchery refuse, or place material in plastic bags and remove from the hatchery area.
(10) Construct a fence around the hatchery area, at least 100 ft (30 m) from it. Post security signs, and keep all gates tightly locked.
(11) *Regular examination of pips and cull chicks required:*
As a precautionary measure to assure that breeders have not become infected with MG, as evidenced by the passage of antibodies through the egg to the chick, a small percentage of the pips and cull chicks on each hatcher tray should be blood-tested. This serum test is only for the presence of antibodies, indicating whether or not the breeder flock has had the disease. As it takes several days after infection in the breeder for the antibodies to make their appearance, the chick test is not a reliable indication that the breeder flock is clean. But if the chick test is positive (antibodies present), it is definite that the breeders have been infected, and as a result some chicks will be carriers. See Chapter 41 for details of test.

Mycoplasma Synoviae (MS) Program

This organism can be completely eliminated by programs followed for the control of *M. gallisepticum.* This method and the method of heat-treating the hatching eggs just prior to incubation are used. Only one need be followed:

(1) Follow the program outlined for *M. gallispeticum* to eliminate the *M. synoviae* organism from the breeder flocks.
(2) Heat-treat the hatching eggs prior to the time they are placed in the incubator. See Chapter 8 for this procedure.

HANDLING HATCHING EGGS

The handling of hatching eggs prior to setting and setting the eggs require certain procedures, to give some assurance that hatchability will be high.

Cooling Hatching Eggs

Eggs to be held several days prior to setting should be kept in a cool room, the temperature being 65°F (18.3°C) and the relative humidity about 75%. But once the eggs are received in the hatchery they should be cooled gradually, rather than suddenly, to the above temperature. The recommendation is that they be kept at room temperature for from 5 to 6 hours prior to placing them in the cool room. This allows the interior temperature of the egg to decrease gradually, thus limiting the stress on the embryo.

Excessive dehydration of hatching eggs can take place in the cooling room unless the relative humidity is maintained at a high level, somewhere in the neighborhood of 75%. Although dehydration of the egg contents will be less at humidities higher than 75%, the added moisture will be absorbed by the corrugated paper

used in constructing egg cases, making them so soggy that they cannot be easily handled

Hatching eggs should be protected from excessive drafts in the egg holding room Egg cases with holes cut in the sides offer the best means of holding eggs However, many eggs now are collected on egg flats in the chicken house, and they remain on these in the egg holding room Such egg flats and eggs should be covered to prevent excessive dehydration as a result of rapid air movement in the egg holding room

Grading Hatching Eggs

Some eggs are graded for quality and size in the hatchery, others are not The decision depends on the type of eggs, breed, and whether they are the product of an integrated operation

Broiler type hatching eggs Eggs from which commercial broiler chicks are to be hatched may or may not be graded The following situations are involved

(1) *When broiler chick production is part of an integrated operation* When the complete production operation is integrated, there is little to be accomplished by egg grading The process is costly, and most integrators would rather the expense be eliminated, even though the resultant chicks may be of slightly inferior quality and some smaller in size

(2) *When broiler chicks are sold to poultry customers* In these cases, chick quality is of utmost importance Small chicks will be objectionalbe to the customer, therefore, many of the hatching eggs must be graded and the small ones removed This process is particularly applicable during the first few weeks the breeder hens are producing hatching eggs, for the egg size is naturally smaller during this period

Egg type hatching eggs Hatching eggs that are to be used for the production of commercial laying type pullet chicks generally are graded for size and quality Most such chicks are not a part of an integrated program, and must be sold to poultrymen who are in the business of producing commercial eggs Like begets like, and any imperfections in the exterior quality of the hatching egg—shape, shell imperfections or shell quality—are likely to be reproduced by the next generation

Breeder type hatching eggs Certain poultrymen are involved with developing and merchandising breeder type chicks Many times pedigree hatching is involved Under these circumstances egg weight and quality are of the greatest importance and eggs must be graded carefully

How Hatching Eggs are Graded

Hatching eggs are graded for weight automatically There are many machines on the market that sort eggs according to designated sizes Some are capable of grading only a few 30-dozen cases per hour, others will handle 50 or more

Eggs are picked up from the egg flats by a pneumatic egg lift which removes an entire layer of 30 to 36 or more eggs at one time They are then placed on the receiver-end of the grader, the sorting process takes place, and eggs are placed di

rectly in the incubator trays by hand. Some egg graders are equipped with egg candlers which may be used for detection of eggs with thin shells, cracked shells, and other imperfections.

Traying Hatching Eggs

Eggs may be placed in the incubator setting trays either before or after they are cooled. Usually they should be trayed as close to setting time as possible. However, this procedure places a heavy load on the labor requirement during a relatively short period of time. A better method is to tray eggs each day, placing the trays in special holding racks designed for this purpose. After traying, the racks are returned to the cooler room for further storage at a reduced temperature.

Recording the source of eggs: At the time the eggs are trayed, a record should be made of the source and type involved. Small cards that fit into a card holder on the tray should be used. All the necessary data regarding the eggs should be written on the cards. If egg settings are made twice-weekly, these cards usually are numbered 1 through 6 to correspond to the 6 settings of eggs in the machines at 1 time.

Use the number 1 card for the first setting, number 2 for the next, etc. These numbers make it easier to select the correct egg trays when the eggs are transferred to the hatcher after 19 days of incubation.

Warm Eggs Prior to Setting

Approximately 6 hours prior to placing hatching eggs in the incubator they should be moved from the egg-cooler room to a room with a temperature of about 72°F (22.2°C). It is advantageous to warm eggs before placing them in the incubator. Placing cool eggs in the machine lowers the incubating temperature for several hours, thus delaying the hatching time of the eggs already in the machine.

Setting Eggs

The time that chick trucks are to leave the hatchery will determine the time that the eggs should be set. Chicks should be at the customer's farm, and on feed, between 12 and 18 hours after the hatch is "pulled." Chicks will have to be removed from the hatcher at 9 to 10 PM, inasmuch as chicks should be delivered early the following morning. Eggs should be set at a time that will allow chicks to hatch and dry off prior to 9 to 10 PM. This will mean the average egg setting time will be about 5 to 6 PM previous.

Remember: Some eggs, as those from Leghorns, require less than 21 days to hatch; others, depending on age, shell quality, size, and other factors will require more or less than 21 days of incubation.

Important: When eggs that are from different breeds, or have different incubation periods, are being set they should be placed in the incubator so that all chicks hatch at the same time, e.g., eggs from Leghorns should be set later than those from meat-type breeders.

Allow time for hatchery chores: Certain hatchery jobs are time-consuming. Detoeing, dubbing, sexing, and other tasks require many hours of labor, and cannot be done simultaneously. When planning the hour to set eggs, ample time should be allowed for these chores after the chicks hatch.

Chicks should not be delivered on a holiday or on Sunday: Watch the chick

delivery day Eggs should not be set so the chicks will have to be delivered on a holiday or on Sunday

INCUBATOR AND HATCHER OPERATION

Good hatches are a must in the hatchery program A small change here and there in the actual incubation procedure will often improve hatchability Remember, additional chicks cost little, high hatchability is the primary basis for a profitable operation

Operation of the Incubator (1-19 days)

Follow these general procedures

(1) *Do not fumigate eggs in the setter* Normally, eggs in the setter should not be fumigated with formaldehyde gas However, if "blow ups' are a problem, fumigation should be done immediately after each group of eggs is set until the problem is resolved Follow the recommendations given earlier in this chapter

(2) *Check the temperature* Use a test thermometer and check the incubator thermometer occasionally If hatches are coming off early or late, the thermometer on the machine may be in error

(3) *Watch the humidity* Chapter 8 shows the relationship between egg size and age and the loss in weight of eggs during incubation Make a study of egg evaporation, remembering that eggs should lose approximately 10 5% of their weight during the first 19 days of incubation

Transferring Eggs

Eggs must be transferred from the setting trays to the hatching trays at the end of 19 days of incubation Usually this involves moving the eggs from the incubation unit to the hatching unit (separate hatcher) In the hatcher trays the eggs are laid on their sides, and given more room than in the incubator trays

When to make the transfer Eggs should be transferred when approximately 1% of the eggs are slightly pipped If some of the eggs are pipping early or late, the setting time should be adjusted to compensate for the variation

How long can eggs be left out of machines? Transferring eggs from the setter to the hatcher may take some time, and eggs will be exposed to room temperature for several minutes Exposure of no more than 15 to 20 minutes will not affect hatchability or chick quality The chick at this period of development is not overly susceptible to such changes in environmental temperature

Transfer the tray card The incubator tray card should be transferred to the hatcher tray at the time of egg transfer This permits continuous identification of the eggs

Candling Eggs

Infertile eggs candled from incubators may have some food value for humans In many countries their use is limited and under strict government regulations In others as the Philippines the partially developed embryo is a delicacy Occasionally, it is a hatchery program to candle the eggs sometime before the end of

19 days of incubation and remove the infertile eggs and dead embryos. In most large, commercial hatcheries the practice is not followed; the cash return from the infertile eggs sold will not compensate for the time and labor involved. The determining factor will be the price received for any candled-out eggs, and the percentage of eggs removed. Some experimental work has indicated that the candling process reduces the hatchability of the remaining eggs. Certainly some will be broken during the additional handling.

Hatcher Operation

Once the eggs are transferred from the incubator trays to the hatcher trays, they are placed in the hatcher for the last two days of incubation during which time the chick liberates itself from the shell. Here the temperature should be lowered, perhaps as much as 2°F (1.1°C), and the relative humidity usually increased. Incubator manufacturers have special instructions for these changes. Their directions should be followed unless there is evidence that a variation would improve hatchability and chick quality.

The newly hatched chick generates a great deal of heat. Care should be taken to prevent heat build-up within the hatcher compartment at the height of hatching. Most hatchers have supplementary ventilators that allow a greater intake and exhaust of air at this time. Some have intricate cooling devices.

Drying the Chicks

At the time the chick hatches it is extremely wet. Chicks must be allowed to dry off in the hatcher, and to fluff out the down. This is a slow process when the relative humidity is 75% or more. To speed up the process, the humidity should be lowered when all the chicks have removed themselves from their shells. Allow approximately 4 to 5 hours for the drying process before the chicks are removed from the hatcher. In some instances the temperature may be reduced at the time the humidity is lowered.

Caution: Do not leave the chicks in the hatcher too long. This will tend to dry them too much, and the dehydration will lower their vigor and vitality. Leghorn chicks dehydrate more rapidly than meat-type chicks of the same size.

HANDLING THE CHICK

Once the chicks have hatched and dried they are ready to be removed from the hatcher compartment. This is commonly known as "pulling the hatch." Several matters of importance should be noted:

Chick Box Sizes

Chick boxes vary in size. The number of chicks to be placed in a box, the outside temperature, and the shipping distance will determine the dimensions. Various sizes holding 100 chicks are as follows:

Standard winter	22 × 18 × 6 in.
Standard summer	24 × 18 × 6 (or 7) in.
Oversize	24 × 20 × 6 in

Many boxes of patented design are on the market Some call for the use of staples to hold them together, others have intricate corner folds that can be snapped together without stapling

In most cases, a box must be separated from the box above it This may be accomplished by glueing a piece of wood (separator) to the cover Some boxes have extensions of the box dividers so that they protrude through and above the lid These act as separators, keeping the boxes apart Although most chick boxes are constructed of corrugated fiber, some are made of plastic These, unlike those of fiber, may be washed, fumigated and reused

Chick Box Pads

Although each box holding 100 chicks is divided into four compartments to prevent the chicks from piling in one corner, chicks still need something they can hook their toes into to prevent them from slipping around in the box Although many materials are used in the bottom of the box, excelsior pads are predominantly popular These pads come in sizes necessary to fit the box being used As each is one fourth the size of the bottom of the chick box, four pads are used for each box

Note Some new boxes do not have dividers, there is but one compartment, and the boxes are satisfactory for short hauls

Removing Chicks from Hatcher Trays

The method employed to transfer the chicks from the trays to the chick boxes will be determined by the type of hatchery involved

(1) *Integrated broiler chick hatchery* As chicks usually are not graded in such a hatchery, the chicks may be counted as they are removed from the trays No additional handling will be necessary unless special chores are involved

(2) *Nonintegrated broiler chick hatchery* Chicks from such a hatchery normally will be sold to the grower Quality and an accurate count are important Chicks should be "scooped from the trays" and counted and graded later

(3) *Commercial egg type pullet chick hatchery* Chicks should be scooped, grading and counting can come later

(4) *Breeder type chick hatchery* Chick quality is important Chicks should be scooped, grading and counting can be a later operation

Calculating Number of Chicks Hatched

When chicks are scooped from the trays it is still possible to get an accurate count of the number of chicks hatched Scoop all chicks except the obvious culls Reference is made to the tray card on which will be recorded the number of eggs set in the tray Next, count the number of eggs left on the trays (infertile, dead in-shell, and pipped), and the number of dead or cull chicks on the tray Subtract this figure from the number of eggs set This will give the number of chicks hatched, which can be recorded on the tray tag After all the chicks have been placed in boxes, the total number of chicks hatched may be calculated by adding the number of chicks hatched as recorded on each tray tag By subtracting the "extras" the number of salable chicks may be calculated

Hardening the Chicks

When chicks are first placed in the chick boxes they are soft in the abdomen, are not completely fluffed out, and do not stand. They must be "hardened" by leaving them in the boxes for 4 or 5 hours. Such hardening makes it easier to grade the chicks for quality, and chicks are more easily vent-sexed.

Grading the Chicks

A definite standard of chick quality must be outlined. No chick below the minimum standard must be allowed to go to a customer. The standard should be the same for all breeds, and functional in all seasons of the year. Do not cut quality when the hatch is poor.

Some standards for quality are:

(1) no chick deformities;
(2) no unhealed navels;
(3) above a minimum weight;
(4) not dehydrated;
(5) down color representative of the breed;
(6) stand up well; are lively.

Extra Chicks

For many years it has been customary to guarantee live delivery of chicks to the customer. So as not to complicate any adjustments after they have been delivered, the hatcheryman has added "extra" chicks to the order to replace any death losses prior to the arrival of the chicks at the farm. The percentage of extras may vary from 1 to 4, with 2 about average. The procedure is to place 102 chicks in a box, and invoice for 100. Thus, 2 chicks are a direct charge against the cost of production.

Record the data: The following data should be recorded for each group of hatching eggs set:

breed
number of eggs set
number of quality chicks hatched
percent total hatchability
number of "grade-outs" (culls)
percent "grade-outs"
percent "extra" chicks given to customer
percent of chicks invoiced of those hatched

Final compilations may be made on a weekly, monthly or annual basis, by breeds or lines of chickens. Seasonal variation in hatchability and other factors may be studied. No hatchery can afford to operate without adequate records.

Hatchery Services

More and more the customer is demanding that certain services be performed at the hatchery. These may be itemized as follows:

(1) sexing
(2) dubbing
(3) detoeing
(4) debeaking
(5) vaccinating
(6) inoculating

Each of these services costs money, unless a charge is made they may run into a large increase in the cost of producing a chick

CHICK DELIVERY

Safe and sanitary delivery of the day-old chick is the last of the many hatchery operations Worldwide, most deliveries are by truck, although other means of transportation are sometimes used in many locations These would include rail and air In some instances the customer may pick up his chicks at the hatchery, using his own means of transportation But most hatcherymen feel they must deliver their chicks in a manner acceptable to their standards of disease prevention, quality control, and in their own vehicles

Chick Trucks

Specialized trucks are used for the delivery of day-old chicks These may be custom built or secured from a manufacturer They must have adequate ventilation and a means of enabling the boxes to be stacked and separated

Size and type The size of the compartment in which the chick boxes are placed will vary Some trucks hold only 10,000 chicks, others, as many as 50,000 or more The size of the truck will be determined by the size of the hatchery, and of course some large hatcheries have several trucks Usually, larger operations hatch chicks on several days of the week, making it necessary to have fewer trucks than if hatching were confined to two days a week

There are three main types of truck bodies

(1) *Cab-over* In these the cab and the body are one unit, enabling the driver to sit in the same area in which the chicks are placed Usually these are smaller units holding a maximum of 20,000 chicks

(2) *Box type* Larger units have a box built separately from the cab in which the driver rides These may hold 50,000 or more chicks In order to safeguard the birds, special controls that can be read in the cab are installed

(3) *Converted buses* School buses and those that are similar sometimes are used as the framework for chick trucks They may be either new or reconditioned As these are equipped with special ventilators, and sometimes air-conditioners, they lend themselves very well to the delivery of chicks

Ventilation system Several thousand chicks generate a great deal of heat, and when chick boxes are confined to a small area, as in a truck body, there must be adequate ventilation to remove the heat Special fans, air intakes, and exhausts must be provided

Heated in winter In exceptionally cold climates the chick compartment must be heated Water, heated by the truck engine, is the usual source of heat, although electric heaters are sometimes used

Cooled in summer In the hot months of the year the flow of air through the van will not produce adequate cooling A refrigeration system must be installed to lower the temperature

Caution: Most of the ventilating fans used for moving air through the chick area are powered by electricity generated by the truck motor. When the motor fails, the supply is cut off. Supplementary units, powered by gasoline engines, must be installed. A load of chicks is too perishable not to take adequate provisions. Even refrigeration units are best powered by a separate engine.

Length of haul: The length of the chick delivery may determine the amount of truck cooling needed. If the hauls are short, and can be completed during the early-morning hours, adequate ventilation, rather than refrigeration, may be all that is needed.

Disinfecting chick trucks: After each chick delivery the chick truck must be thoroughly cleaned, disinfected, and fumigated with formaldehyde gas. Never bring unsanitized trucks back to the hatchery area.

When to Deliver Chicks

Baby chicks should reach the customer's farm early in the morning. Not only is the weather cooler during this part of the day, but the early arrival allows a full day for the chicks to learn to eat and drink, vital necessities in getting them off to a good start.

Log the truck driver: Truck drivers should keep a running log during chick deliveries, especially those involving long hauls. They should record the time they leave the hatchery, all stops, and time of arrival at the farm. Not only does this provide a permanent record, but it keeps the drivers more cognizant of their duties to provide fast and safe arrival of the chicks.

Receipt for chick condition at arrival: Every customer should complete an "Arrival Condition" form supplied by the hatchery. This should include:

(1) number, sex, and breed of chicks delivered;
(2) time of arrival at farm;
(3) number of chicks dead on arrival;
(4) condition of chicks;
(5) condition of the brooding facilities on the farm at time of chick delivery;
(6) other comments.

It should be in duplicate, and signed by both the customer and the driver. The original is returned to the hatchery; the copy is left with the customer.

Shipping Chicks by Air

Many chicks are shipped long distances by air. Special recommendations and instructions are necessary.

Chick box for air shipments: No smaller than 18 × 24 × 7 in. (45.7 × 61.0 × 17.8 cm), or having 2800 cu in. (45,884 cu cm) of volume. Punch out all the holes in the box. When the air temperature is above 70°F (21.1°C), pack 85 chicks to a standard box; when below 70°F (21.1°C), pack 100 to the box.

Timing the air trip
(1) Get to the airport three hours before the plane is scheduled to leave
(2) If airline transfers are to be made enroute do not schedule less than six hours for the transfer Book direct flights if possible

Type of air equipment used in flight Although subject to change on individual flights and schedules, the following is the usual requirement for maximum chick shipments according to the type of plane involved

(1) *Passenger flights*

Make of Plane	Maximum Number of Boxes That Can Be Shipped
B 707	40-50
DC 8	40-50
B 727	25
Caravelle	10

(2) *Freighters* Freighter lines vary in their ability to transport chicks Check the carrier previous to making any shipments Some factors involved are
100 boxes represent maximum loads
Pallets are used for loading
Igloos are sometimes not acceptable for shipping chicks by air Check the carrier, ask where the chicks are to be carried in the plane Belly compartments may not be ventilated Never load chicks in the same compartment with dry ice

Instructions at the airport Probably more chicks die or are damaged at the airport than in the plane Extreme precautions must be taken Comply with the following
(1) The captain of the airliner must be informed that chicks will be on board
(2) Keep chicks in the shade
(3) Keep chicks away from drafts
(4) Do not allow chick boxes to stand outside in cold weather, or in the sun at any time
(5) Do not cover chick boxes with a tarpaulin Never place boxes in a corner of a room Keep in a well ventilated room inside the cargo building
(6) Don't stack boxes over 8 high The heat buildup is too great
(7) Never allow the boxes to become wet They will collapse
(8) Don't stack other cargo on top of chick boxes Leave air space around the boxes This is a must
(9) Keep boxes level at all times

CLEANING THE HATCHERY BETWEEN HATCHES

Cleaning the hatchery between hatches is of primary importance The process must be complete, every piece of equipment must be thoroughly vacuumed, scrubbed, disinfected, and fumigated There are no shortcuts

Cleaning the Hatchers

(1) Remove all racks, trays, and carts.
(2) Vacuum the inside and outside of the hatchers.
(3) Wash the inside and outside of the hatchers.
(4) Scrub the inside walls with a suitable disinfectant.
(5) Return all racks and clean trays from the washroom, and fumigate with formaldehyde at 3X strength

Cleaning the Hatcher and Chick Rooms

(1) Vacuum all debris from the floor and walls.
(2) Wash all floors and walls, then disinfect.
(3) Wash and disinfect equipment other than hatchers.
(4) Fumigate room and equipment with formaldehyde at 3X strength.

Cleaning the Hatcher Trays

All hatcher trays, carts, and racks should be moved to the washroom, washed thoroughly, dipped in a disinfecting solution, then returned to the hatcher compartments (where they are to be fumigated).

Cleaning the Wash Room

(1) After all hatching trays and portable equipment have been washed and disinfected and taken out for fumigation, remove all debris from the washroom. Empty the drain trap. Either incinerate the material removed, or place it in plastic (or similar) bags, and remove it from the hatchery.
(2) Next, wash and disinfect the ceiling, walls, and floors. Do not forget that the washroom probably will be the most infectious area in the hatchery.
(3) Fumigate the room with formaldehyde at 3X strength.

Hatchery Management

One of the implications of hatchery management is that *cost management* should be the criterion of a good operation The manager who can reduce his costs to the minimum will have accomplished one of the greatest of feats Too often the selling price of the chick is geared to factors that are uncontrollable, profit will be increased only by a reduction of the costs of production

There are many factors involved in hatchery management But there is more than just knowing what these factors are, there must be a system to bring them to the attention of the manager on a regular basis Appraising these reports and having the ability to make corrections or adjustments when necessary is the prime function of a capable manager

SECURING HATCHING EGGS

A constant supply of quality hatching eggs is a requisite for a profitable hatchery operation Because hatching eggs usually cannot be purchased on the open market, a careful program must be projected to assure that flockowners will supply a definite number of hatching eggs at specified times The supply must be adequate to produce all the chicks that can be sold, yet there must not be an excess that would have to be liquidated as market eggs at a salvage price

Determining Hatching Egg Need

A sales projection must be made This involves charts and graphs showing the estimated number of chicks, by breeds and sexes, that will be sold each week during the next 18 months It must be kept current, and extended regularly to encompass an 18 month period

The sales projection This is based on the following

(1) *Past history of weekly sales*
What were the sales last year?

(2) Cyclical demand for chicks
Are there seasonal demands for chicks resulting in greater sales during one or more periods of the year? Will sales be greater or smaller during the next year than last year? These must be considered in making the projection

(3) Market potential
What percent of the market (total chick demand) will your hatchery get? Are your sales keeping pace with increased needs in the industry?

(4) New customers
Will new customers be from those with new poultry enterprises, or will they be former customers of competitors? Make a list of all the possible customers in your trade territory Which ones do you now sell? Which ones should you be selling?

(5) Is your hatchery a part of an integrated operation?
Chick sales projections will be on a different basis when the hatchery is a part of integration In these cases the number of chicks needed

each week will be determined by the number of broilers to be processed, or the number of commercial, egg-type pullets necessary to produce a given quantity of market eggs.

Table showing hatching eggs produced per breeder bird: Once the weekly chick sales potential has been detailed, next determine the number of breeders necessary to produce the hatching eggs. A table is necessary to make the calculation. This table will show the number of hatching eggs produced per bird, per week, and projections may be made showing the total number of hatching eggs produced by all breeder flocks. The weekly egg production must be adequate to produce the required number of chicks. Refer to Chapter 23.

Securing Hatching Eggs From Hatchery-owned Farms

When the supply of hatching eggs comes from hatchery-owned farms, there is only the need to house as many breeder pullets as will be necessary to produce the required number of eggs. However, determining the number is an intricate project—one that will require many hours of work if there is to be assurance that the supply of hatching eggs will meet the demand and that there will be no overproduction. When many farms are involved, the process becomes more complicated because only birds of one age may be practical at each unit; birds of other ages will have to be on other farms.

Securing Hatching Eggs Through Contract.—When the hatchery does not own a poultry farm or farms it must make some arrangement with other poultrymen for its egg supply. Such poultrymen usually will provide the buildings, equipment, and labor necessary to raise the pullets and cockerels, and keep the pullets in egg production. The hatchery usually will furnish the day-old breeding chicks, along with the feed and medications necessary to grow the birds. Under these conditions the hatchery and each flockowner will enter into a contract. Under such an agreement the hatcheryman will own the birds at all times; the flockowner only contracts to furnish the houses, equipment, and labor necessary to care for the birds.

There are two types of contracts, involving:

(1) Growing birds
(2) Production birds

Examples of each are given below:

Breeding Stock Growing Contract.—Following is one type of contract.

PULLET FEEDING CONTRACT

This AGREEMENT made this ______ day of ______, by and between ____________, a company existing under the laws of the state of ____________, with central offices located at ____________, hereinafter referred to as "OWNER"; and ____________ of the City/Town of ____________, County of ____________, State of ____________, an independent contractor hereinafter referred to as the "GROWER."

WITNESSETH:

WHEREAS, OWNER wishes to secure mature pullets, and GROWER has labor and facilities for growing, raising, and producing said pullets, and GROWER has farm facilities located at the above address or in the City/Town of ____________, County of ____________, State of ____________.

WHEREAS, GROWER and OWNER desire to contract with one another whereby GROWER will grow and raise said pullets for OWNER

NOW THEREFORE, the parties hereto agree as follows

A OWNER AGREES

1 To deliver to GROWER ____________ on or about ____________, 19______ as the first flock of birds to be raised under this contract, and thereafter to deliver chicks (the number of which is to be determined by OWNER in its sole discretion) to GROWER from time to time as replacement flocks, subject, however to the termination provisions hereinafter contained, and to furnish to GROWER the necessary feed, vaccines, and sanitation products necessary to raise said birds to necessary age to be moved to laying farm

2 To extend to GROWER full cooperation and supervision in operation

3 To select the date and arrange for the marketing or moving of the birds as GROWER'S agent

B GROWER AGREES

1 To furnish all land, buildings, equipment, fuel, electricity, labor, litter, and facilities

2 To use products from OWNER exclusively for use in growing these pullets, to follow OWNER'S Feeding, Management and Sanitation Program, and to give his best care and attention to the operation

3 To keep the birds, feed, medicine, and sanitation products separate and apart from all other poultry

4 To return to OWNER all unused feed, feed sacks, medication, and sanitation products for credit against pullet costs

5 That if any of the following acts or events occur, this contract shall at OWNER option immediately terminate and the GROWER does hereby grant unto OWNER the right to come upon the premises where the birds are situated, without Court Order or other Writ, and to immediately take possession of all chickens, feed, medicine, and sanitation products placed with the GROWER by OWNER and to dispose of same as OWNER, in its sole discretion, shall determine, to wit

(a) In the event GROWER for any reason removes from the above described premises, the chickens, feed, medication, or sanitation products,

(b) In the event OWNER, or its assigns feels unsafe or insecure in the manner in which the GROWER performs this contract,

(c) In the event the GROWER in any manner encumbers or assigns said chickens, feed, medication, or sanitation products,

(d) In the event OWNER in its sole discretion, feels GROWER is improperly or neglectfully feeding, watering, or otherwise caring for said chickens Upon termination of the agreement for breach of a condition mentioned herein, OWNER minimum profit guarantee is void and GROWER does hereby fully release OWNER and its assigns from any claims of any kind or character

C BOTH OWNER AND GROWER AGREE

1 In the event of death of the birds at any time prior to the time they are picked up from the GROWER'S premises, GROWER assumes any

losses due to expenditure of labor, use of land, facilities, and equipment, and the cost of any fuel; OWNER assumes the loss of chicks and the cost of feed and other supplies furnished by OWNER.

2. It is understood and agreed that all chicks and supplies furnished by OWNER, are, and shall remain the sole and exclusive property of OWNER.

D. Upon full performance of this contract by GROWER, OWNER guarantees that the GROWER shall receive ____________ per week times the number of weeks kept by GROWER under this contract. Nothing will be paid for birds that are culled out during moving.

E. The GROWER shall also receive an additional ____________.

____________ GROWER

____________ OWNER

____________ WITNESS

Note: The above contract form is an example only, and is not to be construed as legal, binding, or permissible everywhere. Legal help should be secured before any contract is prepared for use. But the above contract does show the detail that is necessary in these contracts; some are even longer and more involved.

Hatching Egg Production Contract.—Although a great part of a hatching egg contract is identical with the growing contract, there are certain paragraphs that are necessarily different because the PRODUCER (term used, rather than GROWER) is involved with the production of hatching eggs rather than of growing chickens. Some of the paragraphs necessary to deal with this situation are as follows:

(1) Pick up hatching and market eggs at the PRODUCER'S farm no less than twice weekly.
(2) Provide transportation for salable cull birds and fowl from the PRODUCER'S farm.

Payment from the OWNER to the PRODUCER

A. The OWNER and the PRODUCER mutually agree that the OWNER will compensate the PRODUCER for goods and services provided under this agreement:

1. A flat rate of ______ cents per bird, per week until the breeder pullets attain the age of ______ weeks.

2. A flat rate of ______ cents per live bird per week starting when the breeding layers are ______ weeks of age, the number of birds to be determined from mortality charts.

3. In addition to the flat-rate-payment described in A-1 and A-2, OWNER agrees to pay the PRODUCER for eggs produced in accordance with the following:

(A) For such as shall be and are used for hatching purposes ______ cents per dozen
(B) For such as shall be and are used for marketing as table eggs ______ cents per dozen

4 Payments from OWNER to PRODUCER in accordance with the foregoing are to be made as follows .

Bonus For Good Hatchability

Some hatching egg contracts involve the payment of a bonus for good hatch ability This is an incentive program to remunerate the PRODUCER (flockowner) for doing a good job In such cases the contract calls for paying the PRODUCER a bonus for hatchability over a base percentage figure For each 1% hatchability above the base figure the PRODUCER is paid a stipulated amount per dozen hatching eggs

Although the method of using the bonus system in contracts calls for additional records at the hatchery, the endeavor is worthwhile as it tends to keep hatchability at a higher level, and to lower the cost of producing chicks

Financing the Flockowner

On occasion the flockowner undertakes to operate his own hatching egg pro ducing enterprise Not only does he own the land, buildings, and equipment, but he legally owns the birds However, cash costs usually are financed by the hatchery Financing is done uniquely, no actual transfer of money is involved The procedure is as follows

(1) The hatchery furnishes the chicks to the flockowner A chattel mortgage may be taken on the birds as collateral
(2) If the hatchery is a part of an integrated operation, feed to grow the birds also may be furnished under the same conditions as (1), above
(3) Certain medicaments, vaccines, litter, etc may be furnished to the flock owner by the hatchery
(4) The flockowner agrees to pay off his debt to the hatchery by having the hatchery deduct an agreed-on amount from the payment he receives for each dozen hatching eggs sent to the hatchery

EGG AND CHICK RELATIONSHIPS

A part of cost management involves the ability to set the exact number of hatching eggs necessary to produce a designated number of chicks Variations in the hatchability of the eggs from various flocks, season of the year, percent culls, percent extra chicks, and other factors make this calculation a difficult one Therefore, there must be some method for determining the number of eggs to be set that will consider all of these factors The first part of the computation con cerns the relationship between "total hatch" and "salable hatch," as shown in Table 10 1

Example If 100,000 eggs were set, and the total hatchability were 80%, 80,000 chicks would be hatched However, with 2% "grade-outs" (culls), and 2% "extra chicks" the number of "salable chicks" would be 76,863

How to make the above computation

Step 1 Calculate the total number chicks hatched and subtract the number of grade-outs, *i e , if two percent, then subtract two percent from the number of chicks hatched, as*

100,000 eggs set
80,000 chicks hatched (80% total hatch)
1,600 subtract 2% grade-outs (2% of 80,000)
78,400 chicks available after grading

Step 2. For every 100 chicks sold (invoiced), 102 chicks are to be shipped. Thus, the chicks available after grading must equal 102% of those sold (invoiced), as:
78,400 chicks available after grading
76,863 equals number salable chicks.
Divide 78,400 by 102, and multiply by 100.

Table 10.1 shows the relationship between total chicks hatched and salable chicks hatched.

TABLE 10.1

EGGS SET, TOTAL HATCH, AND SALABLE HATCH

Number of Eggs Set	Hatchability									
	Total Hatch	Salable Hatch*	Total Hatch	Salable Hatch*	Total Hatch	Salable Hatch*	Total Hatch	Salable Hatch*	Total Hatch	Salable Hatch*
	70% %	67.26% %	75% %	72.06% %	80% %	76.86% %	85% %	81.67% %	90% %	86.47% %
10	7.0	6.7	7.5	7.2	8.0	7.7	8.5	8.2	9.0	8.7
100	70	67.3	75	72.1	80	76.9	85	81.7	90	86.5
1,000	700	673	750	721	800	769	850	817	900	865
10,000	7,000	6,726	7,500	7,206	8,000	7,686	8,500	8,167	9,000	8,647
100,000	70,000	67,260	75,000	72,060	80,000	76,860	85,000	81,670	90,000	86,470
1,000,000	700,000	672,600	750,000	720,600	800,000	768,600	850,000	816,670	900,000	864,700

*Based on 2% grade-outs (culls) and 2% extras

COSTS

Efficiency in the hatchery has to be measured by unit costs. Therefore, the bookkeeping procedure must be geared to enable the hatchery manager to know his costs on a unit basis. Furthermore, the method involves some degree of cost accounting, although some items in the records may be estimated at times for expediency in arriving at the cost figures.

It is not enough to know the total cost of hatching, delivering, and selling the chicks; the unit cost (cost per chick) of operating the various segments of the business must be known. The major segments are:

(1) Procurement of hatching eggs
(2) Hatching eggs cost
(3) Operating the hatchery
(4) Delivering the chicks
(5) Selling the chicks
(6) General and Administrative costs

Cost to Produce, Sell, and Deliver a Chick

As a starting point in discussing the economics of chick production, an example of the various costs involved is given in Table 10.2.

In Table 10.2, hatchery costs are broken down into the major components of

TABLE 10.2

BREAKDOWN OF HATCHERY COSTS

Item	Cost per Salable Chick Hatched					
	Commercial Egg type Pullet Chick			Commercial Straight run (nonsexed) Broiler Chick		
	Actual U.S $		% of Total	Actual U.S $		% of Total
Egg procurement	0020		1 1	0010		1 3
Hatching eggs	1066(1)		59 1	0665(3)		84 7
Hatchery operation(2)	0360		19 9	0080		10 2
Delivery expense	0080		4 4	0020		2 5
Total		1526			0775	
G&A expense	0150		8 3	0010		1 3
Grand Total		1676			0785	
Sales cost(4)	*0100*		5 5			
Sales G&A cost	0030		1 7			
Total Sales cost		0130				
Total procurement hatchery, and sales cost		1806	100 0		0785	100 0

(1) Eggs @ US$ 48/dozen 75% salable hatch
(2) Includes chick sexing
(3) Eggs @ US$ 60/dozen 75% salable hatch
(4) No sales cost for broiler chicks

the operation It is impossible to manage a hatchery unless these data are known on a regular basis Certain figures, as overhead, G&A expense, and sales expense, may be estimated for making the weekly calculations, but must be accurate when computing the month-end breakdown

Although the figures in Table 10.2 are for hatcheries of large size and efficiency, similar computations may be calculated for other operations

The largest item on the list is egg cost per chick hatched This affects other costs materially for it is based not only on the cost of the hatching eggs, but on the rate of hatchability If more chicks are hatched the hatching egg cost per chick is reduced The same principle affects a reduction in other costs This is true because the total cost to hatch, deliver, and sell a chick is arrived at by divid ing the total expenses for the week, or month, by the number of salable chicks hatched This will be discussed in more detail later in this chapter

Chicks Hatched Per Case of Eggs

Table 10 3 gives the number of chicks hatched per case of eggs when the salable hatchability of the eggs differs These figures are important because many large hatcheries use cases of eggs, rather than dozens, as their cost unit when pro curing eggs, but not for cost analysis

Costs of hatching egg procurement involve those costs associated with getting hatching eggs from the farm to the hatchery They vary with each operation, mainly depending on

(1) Whether the eggs are delivered by the flockowner, or if the hatchery picks them up at its expense
(2) Distance from farm to hatchery
(3) Whether trucks are refrigerated or not

TABLE 10.3

SALABLE CHICKS HATCHED PER 30-DOZEN AND 24-DOZEN CASE OF EGGS

Percent Salable	Salable Chicks Hatched per Case of Eggs 30-Dozen Case	24-Dozen Case
50	180	144.0
55	198	158.4
60	216	172.8
65	234	187.2
70	252	201.6
75	270	216.0
80	288	230.4
85	306	244.8
90	324	259.2
95	342	273.6

Bookkeeping Charges to Procurement

Procurement cost should involve a bookkeeping cost center, with the following being charged to the account:

(1) labor, including all benefits
(2) truck depreciation
(3) truck operating expense
(4) other expense (parking, tolls, uniforms, etc.)

Important: Egg cases, flats, etc., should be charged to hatchery costs rather than to procurement costs.

Calculate Costs on a Per-Dozen-Eggs Basis

Procurement costs must have a unit for cost analysis. Inasmuch as total egg costs are to be on a one-dozen basis, any breakdown should be the same.

Analysis of Procurement Costs

To appraise procurement costs properly, certain figures should be accurately calculated on a monthly basis:

(1) Procurement labor expense per dozen eggs
(2) Procurement truck expense per dozen eggs

The above two items will aid the hatchery manager in comparing his monthly costs over a period of time in determining whether his costs are increasing or decreasing. Unless there is a breakdown on a unit basis the figures are meaningless.

HATCHERY COSTS

The hatchery manager talks in terms of cost involved with hatchery operation rather than with sale price of the chicks. When he produces an 8-cent (US) broiler chick, it means that the total cost of a broiler chick was 8 cents. Thus, money management in the hatchery involves costs, and the breakdown of these is important in lowering the costs.

In analyzing the cost figures, two general categories must be used:

(1) Hatching egg cost
(2) Hatchery operational expense

These two are necessary because the cost of the hatching eggs represents the largest single item, and is the most variable. "Other hatchery costs" usually are quite constant, although there is always room for some reduction through greater efficiency.

Hatching Egg Cost

The cost of hatching eggs fluctuates, and the percentage of the eggs that will produce quality chicks also is variable Because the two factors work together to produce a final effect, the "hatching egg cost to produce a quality chick" is a necessary calculation Some of these relationships are shown in Table 10 4. A study of this table indicates the wide variability in the egg cost to produce a chick Thus, in an analysis of these costs, egg cost and hatchability must be considered separately.

How hatching egg costs are treated: Hatching eggs are purchased, or they come into the hatchery from flocks connected with an integrated poultry enterprise. When they are purchased, the cost is the price paid for the eggs When received from an integrated operation, hatching eggs usually are priced into the hatchery operation (cost center) at their cost of production; no farm profit is added. In an integrated project there is but one profit, when the final product is sold

How hatching egg costs are treated by the accountant Table 10 4 shows

TABLE 10 4

EGG COST AND HATCHABILITY AS THEY AFFECT EGG COST PER SALABLE CHICK HATCHED

% Salable Hatch	U.S Cents per Dozen Hatching Eggs											
	30	35	40	45	50	55	60	65	70	75	80	85
	U.S Cents per Hatching Egg											
	2 50	2 92	3 33	3 75	4 17	4 58	5 00	5 42	5 83	6 25	6 67	7 08
	Egg Cost per Salable Chick Hatched in U.S Cents											
60	4 2	4 9	5 6	6 3	6 9	7 6	8 3	9 0	9 7	10 4	11 1	11 8
62	4 0	4 7	5 4	6 1	6 7	7 4	8 1	8 7	9 4	10 1	10 8	11 4
64	3 9	4 6	5 2	5 9	6 5	7 2	7 8	8 5	9 1	9 8	10 4	11 1
66	3 8	4 4	5 1	5 7	6 3	6 9	7 6	8 2	8 8	9 5	10 0	10 7
68	3 7	4 3	4 9	5 5	6 1	6 7	7 4	8 0	8 6	9 2	9 8	10 4
70	3 6	4 2	4 8	5 4	6 0	6 5	7 1	7 7	8 3	8 9	9 5	10 1
72	3 5	4 1	4 6	5 2	5 8	6 3	6 9	7 5	8 1	8 7	9 3	9 8
74	3 4	3 9	4 5	5 1	5 6	6 2	6 8	7 3	7 9	8 4	9 0	9 6
76	3 3	3 8	4 4	4 9	5 5	6 0	6 6	7 1	7 7	8 2	8 8	9 3
78	3 2	3 7	4 3	4 8	5 3	5 9	6 4	6 9	7 5	8 0	8 6	9 1
80	3 1	3 7	4 2	4 7	5 2	5 7	6 3	6 8	7 3	7 8	8 3	8 9
82	3 1	3 6	4 1	4 6	5 1	5 6	6 1	6 6	7 1	7 6	8 1	8 6
84	3 0	3 5	4 0	4 5	5 0	5 5	6 0	6 4	6 9	7 4	7 9	8 4
86	2 9	3 4	3 9	4 4	4 8	5 3	5 8	6 3	6.8	7 3	7 8	8 2
88	2 8	3 3	3 8	4 3	4 7	5 2	5 7	6 2	6 6	7 1	7 6	8 1
90	2 8	3 2	3 7	4 2	4 6	5 1	5 6	6 0	6 5	6 9	7 4	7 9
92	2 7	3 2	3 6	4 1	4 5	5 0	5 4	5 9	6 3	6 8	7 3	7 7
94	2 7	3 1	3 6	4 0	4 4	4 9	5 3	5 8	6 2	6 6	7 1	7 5
96	2 6	3 0	3 5	3 9	4 3	4 8	5 2	5 6	6 1	6 5	6 9	7 4

how variations in hatchability affect the egg cost to produce a chick. However, the procedure outlined in this table is never used in keeping the financial books of the company. Rather, egg cost is recorded. The total cost of eggs for a given period is then divided by the number of salable chicks hatched from these eggs. This gives the egg cost per chick. The greater the percentage of chicks hatched, the lower the egg cost per chick.

Example: Table 10.5 shows the variations in cost to produce a chick when two groups of eggs have the same cost, but different hatchabilities.

TABLE 10.5

HOW HATCHABILITY AFFECTS CHICK COST
(In U.S. Dollars)

Item	Salable Chicks Hatched	
	75%	65%
Number eggs set	133,330	133,330
Number dozen eggs set	11,111	11,111
Price per dozen eggs	$0.60	$0.60
Expenses		
Egg cost	$6,666	$6,666
Egg procurement	100	100
Hatchery operating	800	800
G&A	100	100
Delivery	200	200
Total	$7,866	$7,866
Number salable chicks hatched	100,000	86,666
Egg cost per chick hatched	$.0667	$.0769
Total cost per chick hatched	$.0787	$.0908

Calculating costs in egg-type hatcheries: When egg-type (Leghorn, etc.) chicks are sold, only the pullet chick is involved; the cockerel is a by-product, and is usually destroyed. Thus, the cost of producing a pullet egg-type chick is twice that of a straight-run (nonsexed) chick, since only half the chicks produced are pullets.

Some hatcheries calculate their hatchery costs on the basis of straight-run chicks, then multiply any final figures by 2 to arrive at the pullet cost. Hatchability is always measured on the basis of straight-run chicks.

HATCHERY OPERATING COSTS

Many costs other than egg costs are involved in the actual operation of a chick hatchery. Usually, these costs are segregated into various categories by the company accountant. Although differing slightly according to the type of hatchery operated, the following represent the main divisions of these accounts.

Divisions of hatchery expense account:

(1) Labor, including all benefits

(2) Heat, light, and power

(3) Depreciation

This represents depreciation on buildings and equipment The various items will have different depreciation schedules to meet the allowable standards of tax authorities

(4) Containers

Represent egg cases, egg flats, chick boxes, and chick box pads Only those actually used during the period of time involved should be expensed

(5) Repairs and maintenance

Small items must be expensed, larger ones, that increase the life of the object, must be capitalized, and not considered an expense item Only the depreciation is expensed

(6) Consumable supplies

These are items that are used up and must be replaced regularly, e g , light bulbs, office supplies, disinfectants, fumigants, etc

(7) Other hatchery expenses (Miscellaneous)

(8) Services

These include debeaking, dubbing, sexing, etc At times some of these involve contract labor (e.g , vent chick sexers) rather than company-employed labor

(9) General & Administrative expense

Certain hatchery expenses are not included in the above items These might be insurance, office expense, telephone and telegraph, management expense, taxes, etc , which are grouped in the G&A account Some of these may be allocated to other than the G&A account, depending on the accountant As an example, management expense could be allocated directly to Item (1), Labor Many G&A costs are "period costs", they are paid once, twice, or more times a year, rather than weekly or monthly, and must be allocated by weeks or months

Important G&A expenses usually are not considered a direct cost of hatchery operation, but they are an indirect cost, and most of these items add to the expense of producing a chick

Hatchery Expense Defined

Most hatchery operators speak of direct hatchery expense as all expense related to operating the hatchery, except G&A Direct hatchery expense, of course, does not include egg procurement, egg cost, delivery cost, or sales cost

Hatchery Expense an Important Analytical Figure

The accountant will keep a record of total hatchery expense, and cumulative figures for the year, but to analyze hatchery expense properly it must be computed on the basis of "salable chick hatched " This figure is the only one that can be used to compare the hatching costs during one period with those of another

Usage of Incubator Capacity

As most hatchery operating expenses, excluding chick boxes and pads, are nearly constant week after week, the ability to keep the incubators full of eggs,

and the hatchery in full operation, is of vital importance in lowering the cost of producing a salable chick. If the incubators are but half-full of eggs, hatchery operating expense will be nearly twice as great on a unit (per chick) basis.

Measuring incubator usage: First, determine the egg setting capacity of the incubators over a period of a week, month, or year, as the case may be. Then compute the actual number of eggs set during this same period, and calculate the incubator USAGE as eggs set against egg capacity, in terms of percent.

CUSTOM HATCHING

Certain hatchery managers may elect to produce chicks on a "custom hatching" basis. In this procedure the hatchery makes a contract with someone who has eggs, but no hatchery; he will supply the hatchery with the hatching eggs, and pay the hatchery a designated amount to set, hatch, box, and deliver the chicks. The hatcheryman has nothing but his building, equipment, and hatchery operating costs involved in the procedure The contract usually is made on the basis of a designated amount per egg set On occasion, it may be based on an amount per per chick hatched

From Table 10 2 these custom broiler-chick hatching costs may be calculated as follows:

Hatchery operating expense	US$ 008	per chick
Delivery expense	002	
G&A expense	.001	
TOTAL, per salable chick	US$ 011	

If hatchability were 75%, it would require 1.33 eggs to produce one chick. US$ 011 divided by 1.33 gives a custom hatching cost of US$ 0083 per egg set

DELIVERY COSTS

One of the obligations of most hatcheries is that the chicks must be delivered to the customer's farm in a satisfactory manner. This is sometimes costly, depending on the distance In some cases, chick deliveries are nearby, and the expense is almost trivial But delivery costs must be divorced from other hatchery expenses, and calculated independently on a "per chick" basis

Delivery is not always by truck, in some countries rail and air are used to a large extent.

The account ledger should include a breakdown of delivery expenses.

Divisions of delivery expense account

(1) Labor, including all benefits
(2) Vehicle operating expense
(3) Vehicle depreciation expense
(4) Air or rail delivery costs
If the hatchery is reimbursed for a part of these expenses, the account should be credited for these reimbursements
(5) Other delivery costs (Miscellaneous) (tolls, parking, driver expense, clothing, etc.)
(6) General and Administrative expense

SALES COSTS

Last in the items of expense in hatchery operation is sales expense. On a chick basis this is a highly variable figure Hatcheries selling egg type chicks usually have a high sales expense, while an integrated broiler-chick hatchery would have practically no sales expense, its endeavors encompassing chick placements, rather than chick sales

Where a definite sales program is involved, the sales expense ledger might be broken down into several categories

Divisions of sales expense account

- labor and commissions
- vehicle operating expense
- vehicle depreciation expense
- salesmen's travel expense
- advertising expense
- other expense (Miscellaneous)
- General and Administrative expense

FACTORS AFFECTING COST OF HATCHING A CHICK

A managerial analysis of the hatchery operation is important There are many items that affect the cost of producing a chick, and a constant watch must be kept on these to keep production costs at a low level Some that affect the operational costs are

(1) Labor efficiency

Automation and labor efficiency are instrumental in reducing labor costs One index used to measure labor efficiency is "chicks hatched per hatchery employee" Although the figure can hardly be used to compare one hatchery with another, it does offer a method of determining the weekly or monthly variations with a single operation over a period of time

(2) Wage rate

The hourly cost of hatchery labor is an important criterion of hatchery costs In many instances it will be necessary to improve efficiency to offset increases in the wage rate

(3) Managerial efficiency

Just how good is the manager? Can he direct people and conduct good business procedure? Is he cost-conscious?

(4) Utilization of incubator capacity

If there are cyclical demands for chicks, what happens to costs during the "off-season"? Do they increase to such an extent that profits during other parts of the year are consumed?

(5) Hatchability of the eggs

Probably no single factor is as responsible in determining chick costs as hatchability It is difficult to be competitive when hatchability drops

(6) Size of operation

Generally, the cost of hatching a chick is lower in larger hatcheries This is particularly true in hatcheries producing egg type, commercial

pullet chicks, where seasonal variations in the demand for chicks is greater than in those hatcheries selling meat-type broiler chicks.

(7) Age and condition of hatchery
Both of these affect results, either efficiency of operation, or hatchability. Old-fashioned operations are apt to be less sanitary; chick quality may be impaired.

(8) Depreciation costs
Hatcheries should be well equipped, clean, and efficient. Luxuries in construction are not necessary; they only add to the depreciation cost.

(9) Discounts on purchases of supplies
Every little bit helps. Discounts should be taken. Generally, it is economical to borrow money when necessary to take advantage of cash discounts on purchases.

(10) Utility rates
Large amounts of electricity are used in a hatchery. The power rate is important. Wire the hatchery to take care of power (commercial) and volume rates; incubators and motors should have a separate circuit and separate meter.

HATCHERY MANAGEMENT RECORDS

To manage a hatchery efficiently, and to keep costs to a minimum, the manager must have certain records after each hatch, each week, and at the end of each

TABLE 10.6

MANAGER'S HATCH REPORT

Hatch date________

Flock		No. Cases Set	No. Eggs Set	No. Total Chicks Hatched	% Total Hatch		No. Grade-outs	% Grade-outs	% Extras	Salable Chicks	
Number	Wks. in Prod.				Act.	Std.				No.	%
TOTAL											

Egg cost per dozen eggs ______	Total chicks sold ______
Egg cost per salable chick ______	Prime product chicks destroyed ______
Other costs per salable chick (est.) ______	TOTAL salable chicks hatched ______
TOTAL cost per salable chick ______	Estimated number salable chicks next hatch ______

month Good management is the result of pinpointing inefficiencies and correcting them

Manager's Hatch Report

Table 10 6 is a form containing the data that should be supplied to the manager after each hatch

The manager should not be confused with too many reports He needs only those necessary to make major decisions, minor decisions will be the result of dis cussions with his employees The Manager's Hatch Report is initiated immediately after every hatch, it must be current to be effective Naturally, all cost figures, other than the egg cost to hatch a chick, are best given as estimates, based on actual costs incurred the previous month

Manager's Monthly Hatchery Report

At the end of the month the manager should be supplied with an accurate report of his operating costs, along with a month-end report of factors involving hatch ability There also may be a cumulative report for the year

What the month end report should include The report at the end of the month should be in three segments, (1) hatchability data, (2) cost analysis, and (3) other data The following figures under each category should be on the report

(1) *Hatchability data*

- hatchery egg setting capacity for the month
- number of eggs set during the month
- percent hatchery egg capacity utilized
- total chicks hatched for month
- percent total chicks hatched for month
- standard hatchability for month
- percent chicks culled (grade-outs)
- percent extra chicks
- *total salable chicks hatched*
- percent salable chicks hatched
- number of salable chicks destroyed

(2) *Cost analysis*

- total procurement cost per case of eggs
- egg cost per salable chick hatched
- total cost to hatch one salable chick
- total cost to deliver one salable chick
- total cost to sell one chick
- TOTAL cost to hatch, deliver, and sell one chick

Note These data should be completed for each breed involved It is impossible to segregate problems if chicks hatched from various breeds are grouped together

(3) *Other data*

- total procurement employees
- total hatchery employees
- total delivery employees
- total sales employees

chicks hatched per hatchery employee
chicks delivered per delivery employee
number of hatches for the month

What Does Management Mean?

In this chapter the matter of "cost management," rather than "profit management," has been stressed. No enterprise can long exist unless costs are kept at a minimum. The difference between sales price and cost represents profit. Profit ensues because the product sold commands a certain selling price, determined to a great extent by the competitive situation in the market, or perhaps the law of supply and demand. If the market price is stabilized, the only possible means of increasing profit is to reduce unit production costs. Such a reduction is the result of many decisions of management: increase sales, lower labor costs, increase hatchability, lower overhead, correct inefficiencies, etc.; but the important point to remember is that over a long period profit will be generated when production costs are lowered.

Hatchery management decisions cannot wait until the month-end or year-end. Inefficiencies cannot continue day after day, hatch after hatch. They must be handled and corrected as fast as they occur. Thus, expediency of getting hatchery reports to management is the essence of a proper job. Any delays will only increase problems and costs. This point cannot be overemphasized.

Poultry Housing

Chickens, being warm blooded animals, must be kept in an environment that is optimum They cannot withstand great extremes of climate Correct poultry housing is a requisite of any good program of poultry management, but the requirements of adequate housing are many and detailed

PHYSIOLOGICAL FACTORS AND ENVIRONMENT

Regardless of the environmental temperature, the bird has a self regulating process by which it tends to keep its own temperature within certain limits This is known as *homeostasis* Body temperatures vary with the age, sex, and movement of the bird With the resting individual, heat is generated by voluntary muscle activity and metabolic processes However, heat is lost from the body by a variety of things exercise, eating, drinking, digestion, egg production, season of the year, time of day, environmental temperature, air velocity, and humidity Any of these variations will cause the bird to call on her ability to maintain her normal body temperature The governing mechanism is the hypothalamus, a part of the brain

Heat Loss

As the bird is continually producing heat, there must be some means of liberating it from the body, otherwise the body temperature would increase Methods of heat liberation are

(1) radiation	(4) vaporization of water
(2) conduction	(5) fecal excretion
(3) convection	(6) production of eggs

Heat Production

Usually, about 75% of all heat generated by the bird is lost through radiation, conduction, and convection But the rate of loss is influenced by the ambient temperature When the weather is cool these systems do their job well, but when environmental temperatures are at, or near, the body temperature of the bird, they operate but little or not at all The hen's ability to dissipate heat is influenced by the skin temperature rather than by the body temperature As the temperature of the air surrounding the bird decreases, the blood vessels in the skin contract, thus reducing the flow of blood, which in turn acts to reduce the amount of heat lost from the body When the temperature of the surrounding air increases, the blood vessels dilate increasing the flow of blood, thus increasing the amount of heat lost

Panting necessary at high environmental temperatures When radiation, conduction, and convection are unable to transfer all the heat produced, the next mechanism is called upon This is *panting*, which is a means of bringing more outside air in contact with the membranes of the respiratory tract Heat is removed from the body by the incoming air itself, and because the outside air has a lower humidity, more moisture is absorbed

from the bird, along with its content of heat. This is known as *insensible heat loss.*

At an average humidity, birds will begin panting when the ambient temperature reaches 85°F (29.4°C). As the outside temperature increases above this figure, so will the respiratory rate of the bird (panting), and more heat is eliminated from its body.

Panting and dehydration: The increase in the breathing rate is accompanied by an increase in the loss of moisture from the body. To compensate for this loss, the bird drinks more water to avoid dehydration. Eventually, the bird drinks more water than it can exhale, and the surplus is excreted through the droppings. The amount of moisture in the ambient air (humidity) also affects the panting rate; the higher the humidity the more rapid the respiration.

High temperatures and high humidity: Chickens cannot withstand concurrent high temperature and high humidity, regardless of their age. When the surrounding air is moist, it cannot absorb as much moisture from the lungs; consequently the bird must pant faster. Similarly, when the outside temperature is high the respiration rate is increased. When both high temperature and high humidity are present, the bird may not be able to pant fast enough to remove the heat from its body. Prostration and death occur when the body temperature rises above the physiological maximum.

Heat production and feed consumption: As the body temperature begins to rise during increases in outside temperature, the bird also makes other adjustments to keep its body temperature normal. Feed consumption is reduced as the ambient temperature rises; it increases as the temperature lowers. In turn, growth and egg production are decreased.

Activity affected: As the outside temperature changes, so does the activity of the bird. Movement is lessened during hot weather in the bird's endeavor to generate less heat. The bird rests more, as evidenced by less eating, less mating, and more sitting rather than standing or walking. More molting of surface feathers occurs. Conversely, when the air temperatures are low the bird induces greater production of body heat through increased activity, greater feed consumption, and more fluffing of the feathers.

Heat and Moisture Production

The amount of heat and moisture produced by birds when the ambient temperature increases or decreases is highly variable. Table 11.1, shows this clearly for a flock of Leghorns laying eggs at the rate of 75% hen-day production and weighing 4.3 lb (1.95 kg).

Table 11.1 shows that as the outside temperature increases, the heat from the hens decreases. For each 1% increase in the temperature, the heat decreases 0.5%. In other words, the colder it gets, the more heat the bird generates in trying to maintain its body temperatures; the hotter it gets, the less heat it produces. Furthermore, as the air temperature increases, the respired moisture increases markedly, with a reduction in the fecal moisture. A great part of the difference in respired moisture is due to the fact that the birds are consuming more water.

TABLE 11 1

HEAT AND MOISTURE PRODUCTION BY 1000 LAYING HENS

Temperature °F	°C	Total Heat from Hens Btu per Hr	Water from Hens per Hour Respired Lb	Kg	In Droppings Lb	Kg
25	3 9	46 000	6 3	2 86	14 5	6 58
35	1 7	45 000	8 3	3 76	14 5	6 58
45	7 2	38,700	8 4	3 81	12 9	5 85
55	12 8	38,700	10 4	4 72	12 8	5 81
60	15 6	38,700	11 4	5 17	12 7	5 76
80	26 7	38 500	14 3	6 49	14 4	6 53
95	35 0	24,500	20 0	9 07	10 3	4 67

Source H Ota and E H McNally 1963 Design Criteria for Laying House Moisture and Temperature Control Commercial Egg Clinic Texas A & M College Station, Texas

Temperature and Water Consumption

Chickens will consume about 75% more water at 90°F (32 2°C) than they will at 70°F (21 1°C) Although things other than temperature will affect water consumption, such as amount of salt in the diet, energy value of the ration, and pelleting the feed, it must be remembered that as air temperature increases, feed consumption drops and water consumption rises

Rule of thumb At 70°F (21 1°C) chickens will consume 2 lb of water for each 1 lb of feed consumed (or 2 kg of water for each 1 kg of feed consumed)

Water consumption and other data in relation to air temperature are given in Table 11 2

TABLE 11.2

TEMPERATURE AS IT AFFECTS WATER AND FEED CONSUMPTION AND WATER ELIMINATION

Item	House Temperature				
	Degrees Fahrenheit				
	40	60	70	80	100
	Degrees Centigrade				
	4 4	15 6	21 1	26 7	37 8
Pounds of water consumed per pound of feed consumed	1 7	1 8	2 0	2 8	4 5
Ratio of water and feed consumed to feces produced (lb)					
Leghorn	1 9	2 0	2 1	2 2	2 3
Meat type	1 6	1 7	1 8	1 9	2 0
Water content of feces (%)	74	75	77	79	81

Temperature and Broiler Production.—The changes that occur in heat and water output during the growth of broilers are shown in Table 11 3 These data were taken from a flock maintained at approximately 70°F (21 1°C) The figures show the rapid reduction in the heat production per pound (or kilo) of body weight as the bird grows older, although there is an equally rapid increase on a bird basis

As chicks mature, they consume more water per unit of weight, and the fecal output of water increases correspondingly. Based on these figures and the "rule of thumb," 1,000 broilers eliminate about 7,000 lb (3,175 kg) of water during their eight weeks of growing. At higher environmental temperatures, the water elimination would be proportionately greater.

TABLE 11.3

HEAT, MOISTURE, AND FECAL PRODUCTION PER 1000 BROILERS RAISED AT 70°F (21.1°C) BY WEEKS

Age of Birds	Avg Body Weight		Heat Output per Hour			Water Output per Day per 1000 Birds		Fecal Output per Day per 1000 Birds	
Weeks	Lb	Kg	Per Lb B.t.u.	Per Kg B.t.u.	Per 1000 Birds B.t.u.	Lb	Kg	Lb	Kg
2	0.45	0.20	26	11.8	11,700	130	59.0	70	31.8
3	0.75	0.34	23	10.4	17,250	200	90.7	110	49.9
4	1.30	0.59	18	8.2	23,400	280	127.0	170	77.1
5	1.75	0.79	14	6.4	24,500	350	158.7	215	97.5
6	2.40	1.09	13	5.9	31,200	400	181.4	260	117.9
7	3.00	1.36	10	4.5	30,000	470	213.2	315	142.9
8	3.75	1.70	10	4.5	37,500	500	226.8	370	167.8

Source: C. E. Lampman *et al.*, 1967, Environmental Control for Poultry Housing, Idaho Agr. Expt. Sta. Bull. *456*.

The Environmental Problem

The above information points out the problems involved with proper poultry housing. Briefly, they may be itemized as follows:

(1) Provide warmth to the birds during periods of cold weather.
(2) Cool the birds during hot weather.
(3) Reduce the humidity.
(4) Provide adequate air movement through the house.
(5) Remove the ammonia from the house.

Years ago a discussion of poultry housing dealt with those factors necessary to give shelter from the sun and rain, and a temperature above freezing. But today, an environment must provide more than this. Adequate housing is that which is necessary to supply an environment that meets the optimum requirements for the greatest bird behavior either through growth, freedom from stress, fertility, or egg production. Today, poultry housing is indeed, a scientific subject.

INSULATING THE POULTRY HOUSE

Regardless of the type of poultry house, there must be some exterior insulation. This is a requisite for open-sided houses as well as for those that are environmentally controlled. Most of the insulation is confined to the roof, as this is the area of greatest heat loss during cold weather and the area that the sun's rays strike during hot weather.

R-values

The efficiency of any insulating material, or combination of materials, or type of construction, is rated as its ability to resist the transfer of heat through it.

There are many materials or combinations of materials used to insulate poultry houses, and the resistance of these materials to the transfer of heat has been given a practical term known as *R value*, or thermal resistance. These are given in Table 11.4.

TABLE 11.4

R VALUES OF VARIOUS BUILDING MATERIALS

	Thickness In	Thickness Cm	Resistance Rating
Air Space	3/4	1.9	0.91
Asbestos board	1/4	0.6	0.13
Blanket insulation	1	2.5	3.70
Blanket insulation	2	5.1	7.40
Blanket insulation	3	7.6	11.10
Cinder block	8	20.3	1.73
Concrete	10	25.4	1.00
Fill insulation			
Shavings	3⅝	9.2	8.85
Shavings	5⅝	14.3	13.70
Sawdust	3⅝	9.2	8.85
Sawdust	5⅝	14.3	13.70
Fluffy rock or mineral fiber	3⅝	9.2	13.40
Insulation board (cork board)	25/32	1.9	2.60
Insulation board (typical fiber)	25/32	1.9	2.37
Plywood	3/8	1.0	0.47
Roofing (roll 55 pound)	1/8-1/4	0.33-0.64	0.15
Sheathing	3/4	1.9	0.92
Shingles			
Asbestos			0.17
Wood			0.78
Siding drop	3/4	1.9	0.94
Surface inside			0.61
Surface outside			0.17

The value of insulation in an environmentally controlled poultry house is obvious, but when the sides of conventional houses are open, the use of insulating material in the ceiling becomes questionable. However, the practice is becoming more common, most new conventional houses have been provided with some type of roof insulation, either directly against the roofing material, or by constructing an attic in the gable. Although the effects of such insulation are of little value when there is good air flow across the birds, as during the period of strong natural air currents, it must be remembered that many times the winds do not blow, and curtains are often used on this type of house to prevent cold air from entering.

Vapor Barrier

To be effective, an insulating material must be dry, since any moist material conducts heat and cold. To prevent moisture from penetrating the outside wall or roof and wetting the insulation, a dead air space between layers of material may be provided. This space is known as a vapor barrier. However, during the last few years new materials that take the place of the dead air space have come on the market. These materials are porous and do not conduct moisture. Therefore, they may be placed directly against other material, which makes them easy to install.

Sometimes these insulating materials are placed on the underside of the rafters, thus leaving an air space between them and the roof sheathing or covering.

How Much Insulation?

Obviously, there should be more insulation in cold climates than in warm or hot. But the average should show the following R-values:

	R-value for	
Type of climate	*Roof and ceiling*	*Walls*
Hot climates	4	2
Medium climates	8	2.5
Cold climates	12–14	8–10

Determining the R-value of Insulation

Because each type of wall or roof covering has an R-value, the sum total of the R-values of the materials used will give the R-value for the wall or roof. Using Table 11.4, an example of the resistance value of a wall has been calculated below:

Outside surface	R-value of 0.17
Shingles	0.78
Building paper	0.15
Sheathing	0.92
Inside surface	0.61
Total resistance rating	2.63

If the wall were insulated with a 2-in. blanket of insulating material plus a dead-air space, vapor barrier, and inside sheathing, the addition would be calculated as follows:

Dead-air space	R-value of 0.91
Blanket insulation	7.40
Vapor barrier	0.15
Sheathing	0.92
Total insulating resistance rating	9.38
Wall	2.63
Total insulating resistance rating of wall and insulation	12.01

Attic Insulation

By running stringers across the house on top of the studs, then lining the bottom of the stringers with some sort of insulating material, it is possible to construct an attic in the house. This has the advantage of creating a large vapor barrier or air space in the gable. But the size of the air space is not correlated with any insulating value. A 4-in. dead-air space probably would provide as much insulation as an air space 4 or 5 ft in depth. Furthermore these attics become extremely warm, and although this has some advantage in the cold months of the year, it is a disadvantage during the hot summer months. To remove the hot air from the attic some sort of ventilation must be provided, usually suction cupolas in the gable and air entrances in the attic at the end of the house.

In environmentally controlled poultry houses, the air entering the pens during the cold winter months is first brought into the attic, warmed, then drawn into

the area where the chickens are During the summer months, air is admitted directly from the outside instead of through the attic

MOISTURE IN THE POULTRY HOUSE

Moisture in the poultry house constitutes one of the greatest problems of adequate poultry housing This moisture is due to fecal elimination of water and also to that contained in the respired air About the only way it may be removed from the house is to increase the movement of air through the building But the relative humidity governs the amount of moisture the air will absorb When the relative humidity is low, the air will take up more house moisture than when it is high See Chapter 5 But all moisture in the poultry house is not in the air, the bulk of it is in the litter Fresh fecal material will contain from 75 to 80% of water, but the amount of water in the litter is more variable In dry climates it may be as low as 5 to 10%, in wet, it may rise to 70 to 80% It is difficult to give a figure for normal litter moisture, but for growing birds it should be between 20 and 50% For older birds it should be between 10 and 30%

Water in Fecal Material

At 70°F (21 1°C) a chicken will drink about 2 lb (or 2 kilos) of water for each pound (or kilo) of feed it eats, and 65 to 70% of the water consumed will appear in the fecal material At higher ambient temperatures the amount of water consumed, and the amount excreted, will increase greatly

Elimination of moisture from the poultry house becomes much more of a problem during cold weather than in warm weather because it is necessary to retain the heat in the poultry house by reducing the flow of air through the building Soon the air carries more moisture, evaporation is reduced, and the litter becomes wet

Amount of Fecal Material

At 70°F (21 1°C) the amount of fecal material will be about 25% greater than the weight of the feed eaten Ambient temperature will alter this percentage

TABLE 11.5

RELATIONSHIP BETWEEN FEED AND WATER CONSUMPTION AND FECAL MATTER
(For 100 Leghorn hens)

Item		Degrees Fahrenheit		
		40	70	100
		Degrees Centigrade		
		4 4	21 1	37 8
Feed consumed per day	(lb)	27	22	17
Feed consumed per day	*(kg)*	*12 3*	*10 0*	*7 7*
Water consumed per day	(lb)	40	44	76
Water consumed per day	*(kg)*	*20 9*	*20 0*	*34 5*
Droppings produced per day	(lb)	38	31	40
Droppings produced per day	*(kg)*	*17 2*	*14 1*	*18 1*
Fecal water produced per day	(lb)	28	24	32
Fecal water produced per day	*(kg)*	*12 7*	*10 9*	*14 6*

Birds will eat more during cold weather than during hot, but will drink less water; and water makes up an important part of the weight of fecal material.

Computation and total fecal material: A breakdown of feed and water consumed by 100 4-lb Leghorn hens and the composition of their droppings is shown in Table 11.5.

Although many data relative to the amount and composition of the fecal material have been reported, the results are highly variable because there are so many factors involved in the production of fecal matter. Humidity, temperature variations between night and day, composition of the feed, feed consumption, amount of salt in the feed, and many other factors influence the figures. Table 11.5 presents data that are the result of average conditions. Of material significance in this table is the great variation in feed and water consumption when the environmental house temperature changes. As the temperature rises, feed consumption decreases and water consumption increases.

Moisture Buildup in Poultry House

Unless means are provided to remove it, moisture will increase in the poultry house when

(1) Water consumption by the birds increases.

(2) House temperature decreases.
Decreasing the temperature reduces the ability of the air to hold moisture; therefore less fecal moisture will be removed from the litter. The air holds less respired moisture; the excess is absorbed by the litter.

(3) Humidity of the air in the house increases.
As the humidity increases, the air takes up less water vapor, and more fecal and respired moisture are absorbed by the litter.

(4) The salt content of the diet increases.
Birds drink more water as the salt content is increased.

(5) The energy value of the feed is reduced.

(6) A feed is pelleted.
Water consumption is increased when feed is compressed, either as crumbles or pellets.

(7) Drinking water is contaminated by microorganisms.

(8) Birds are kept in cages.
Caged birds consume more water than those kept on the floor.

TABLE 11.6

RESPIRED AND FECAL MOISTURE ELIMINATION

Item	Degrees Fahrenheit 40 / Degrees Centigrade 4.4 (%)	70 / 21.1 (%)	100 / 37.8 (%)
Respired moisture	38	40	60
Fecal moisture	62	60	40

Respired moisture Although the fecal material contains a large amount of water, respired moisture is great too At 70°F (21 1°C) the relationship between the two is 60% in the droppings and 40% in the respired air But as temperatures increase, a higher percentage of the water is lost from the body as respired moisture The variations are shown in Table 11 6

AMMONIA CONCENTRATION

The ammonia in a poultry house can become troublesome when the concentration is high Not only is ammonia nauseating to the caretaker, but it also irritates his eyes Ammonia is measured in parts per million (ppm) Normally, 15 ppm will prove uncomfortable for man, 50 ppm for eight hours is considered the maximum allowable concentration For chickens, continuous concentrations above 20 ppm probably are injurious, for short duration, the concentration may be higher

How to measure ammonia concentration On the market is a kit for measuring ammonia concentration in ppm A special impregnated paper is moistened and held in the poultry house It turns various colors from orange to blue, depending on the concentration of ammonia in the atmosphere, and the color can be correlated with the ppm present

Reducing ammonia fumes Ammonia in the poultry house may be reduced by increasing the amount of air flowing through the building—the usual procedure—or by removing the litter more often One third cfm per pound of bird is said to be ample air movement through the poultry house to keep the ammonia below its tolerance

OPEN-SIDED POULTRY HOUSE

Most of the poultry houses in the world are conventional, that is, they rely on the free flow of air through the house for ventilation For those using this type of house, certain requirements must be met if the house is to provide an adequate environment Care in following these rules during the course of construction will avoid pitfalls later

Width of house The width (from front to back) of the open-sided poultry house should be about 32 ft (9 75 cm) Many are being built that are 30 ft (9 14 m) wide Houses that are wider than this will not provide ample ventilation during hot weather This width recommendation is basic for growing birds, broilers, or for laying hens

Height of house Most open-sided poultry houses have a stud that is 8 ft (2 44 m) long This then represents the distance from the foundation to the roof line In areas where the temperature is exceptionally high throughout the entire year, the stud length should be increased to 10 ft (3 05 m)

Length of house Poultry houses may be almost any convenient length The terrain on which they are to be built often determines the length, rolling land means more grading before construction can start As automatic feeding equipment will limit the length of the poultry house, the equipment manufacturer should be consulted about the length of chain the gears of the automatic feeder will motivate Many times the feed

hopper is placed in the center of long houses to provide better use of automatic feeders.

Shape of roof: Practically all poultry houses built today have a gable roof, the pitch varying from one-quarter to one-third. In most instances, a good overhang should be provided. This helps protect the inside from driving rains, and affords interior shade during much of the year.

Insulation: Even with the conventional poultry house, it is well to provide some type of insulation. The roof may be insulated, using special products for this purpose, or an attic, or partial attic, may be installed. Attics should be ventilated with suction cupolas, or by vents.

Foundation: A solid and adequate foundation should support the building. Concrete, concrete blocks, bricks, or other permanent and termite-proof material should be used. Evenness of the foundation is important, for it will determine the evenness of the completed structure.

Floor: With certain disease-control programs, a concrete or similar floor is mandatory. It is also necessary when the soil is very dense and can absorb and transfer moisture from lower subsoil. But in certain areas, where the soil is sandy, and where commercial broilers or commercial layers or breeders are kept, a concrete slab is not used when birds are placed on the floor.

Doors: Doors at the end of the house should be large enough for a truck or tractor to pass. Such equipment will be used when the house is cleaned.

Front and Back Sides

With this type of house most of the area in the front and back of the house is open. The height of the opening will be determined by climatic condition, and by the type of bird being housed, as follows:

Broilers and young chicks: From one-half to two-thirds of each side is left open, the exact amount being determined by summer and winter temperatures. When both heat and cold are to be dealt with, the size of the opening should be medium. Where heat is continuous, the opening should be larger; sometimes almost all the front and back is left open.

Growing birds and layers: The opening size is greater for older birds. They should be provided with more air because bird density is greater, and more ventilation is necessary.

Cage houses: Houses equipped with cages necessitate the greatest amount of air movement. The bird density is the greatest of any type of flock. Sides should be almost completely open.

Curtains during cold weather; Young chicks and older birds should be given some protection during periods of cold weather and extreme winds. This is usually provided by curtains made of some durable and plastic-like material. They are placed on rollers that run the length of the building and hung so that the entire curtain may be rolled up or down by cables and a winch located at one end of the building. This construction makes it easy to regulate the size of the opening according to weather conditions—an almost indispensable provision. The curtain material, cable, and winch are made by several manufacturers.

Cooling the Open sided House

As long as there is some wind moving, the open sided house works well in warm weather, but in hot weather the warm breezes may be detrimental to the birds It is when the wind stops that trouble begins The buildup of heat within the building is quick, and at inside temperatures of 95° F (35° C) and above, the birds are distressed, and suffocation begins as their body temperature rises above the point of toleration One or more methods of comforting the birds must be employed

(1) *Sprinkle the house roof* Circulating sprinklers may be installed at the point of the roof

(2) *Sprinkle the ground area outside the house* This tends to cool the air around the house, but it also increases the humidity, a detriment to bird cooling

(3) *Use foggers in the poultry house* Foggers emit a fine mist of water By placing them over the birds the mist keeps the chickens wet, and helps keep them cool

Note Foggers do not lower the temperature within the house Their great function comes because the birds are wet If foggers are not available, a fine spray from a garden hose may be used to wet the birds

(4) *Fans* Undoubtedly, the natural movement of air over the birds helps to lower their body temperature It dissipates body heat more quickly, and removes the exhaled moisture Increased air movement usually is necessary during hot weather, particularly when natural air movement ceases Fans may be placed on the windward side of the poultry house to increase the velocity of air as it blows through the building But when the outside temperature is unusually high, it may be better to place the fans inside the house, to blow the air lengthwise of the building High speed fans are better than low-speed, regardless of where placed

The Wind-chill Factor

Degree of cold is a relative thing in the case of a human being How cold one feels is determined by the loss of heat from the surface of the body Obviously, the lower the ambient temperature the more heat lost from the body, and the colder the human body feels But if the surrounding air is blown over the surface of the body one not only feels colder because heat is dissipated more rapidly, but because moisture is evaporated more quickly from the skin For instance, if one stands in still air at 35° F (1 7° C), he feels chilly But if the air movement over the person is increased to 10 miles per hour, he feels as though the temperature were 21° F (16 1° C) If the air is speeded to 35 miles per hour, he feels the equivalent of still air at 3° F (-16 1° C)

Although these are known facts for human beings, the chicken has no sweat glands, thus there is little, if any, evaporation from the surface of the body But we do know that the movement of air over the birds, regardless of how it is pro duced, makes them more comfortable in hot weather, as heat loss is increased Similarly, the birds must feel colder during cold weather when air speeds are in creased Thus, increasing air movement during extemes of heat, and protecting

the birds from the wind during cold weather, are important factors in ventilating the open-sided house.

CONTROLLED-ENVIRONMENT HOUSE

A controlled-environment house is one in which inside conditions are maintained as near as possible to the bird's optimum requirements. This necessitates a completely enclosed house with no windows. Air is removed from the house by exhaust fans, and fresh air brought in through intake openings. Artificial light, rather than natural daylight, is used to illuminate the interior. Where high outside temperatures are involved, some method of cooling the inside of the house should be provided. Usually the houses are not heated in the cooler months, the heat from the birds being used to keep inside temperature within a comfortable range.

Much of the structural makeup of the environmentally controlled poultry house is similar to that of the house with open sides. It should have a good foundation and a gable roof. Insulation is a must; both the sides and the top should be given protection. The overhang of the roof need not be as great because the sides are completely covered. But ventilating a completely enclosed house is difficult. Details must be worked out so that air movement is adequate during both hot and cold weather, a complicated procedure.

Width of House

Because air is exhausted from the environmentally controlled house, rather than being removed by natural air movements as in the open-sided house, the width (front to back) of the enclosed house may be greater. These houses should be about 40 ft (12.2 m) wide. Most ventilating systems will adequately remove air from a house of this width, but there may be difficulty with those that are wider.

Feeding equipment may determine house width: Many different types and ages of chickens are housed in a controlled environment, each requiring a different amount of feeder and floor space. See Chapters 13–16. Because some houses incorporate automatic feeding equipment in which the feed is drawn around the interior of the house by a chain in a feed trough, these operate in *loops*; that is, the trough makes one complete circle in the building.

Feeding space defined: Trough feeding space is the linear amount of space provided by *both* sides of a trough; that is, a trough 12 in. (30.5 cm) long provides 24 in. (61 cm) of feeding space.

Other types of automatic feeders: Other automatic feeders incorporate single lines of feed trough; some use a tube and trough; others have a tube with pan feeders. See Chapter 12.

Calculating house width from type of feeder: Consider that you take one running foot of floor space from the house. One loop of feeder (two troughs) in the running foot will provide 48 in. (121.9 cm) of feeding space. If each bird requires 3 in. (7.6 cm) of feeder space, one loop of feeder will care for 16 birds (48 ÷ 3). If each bird needs 2.5 sq ft (0.23 sq m) of floor space, 16 birds will require 40 sq ft (3.7 sq m) of floor space; thus the house should be 40 ft (12.2 m) wide to utilize the feeder space available.

The house width may be determined similarly when other types of automatic feeding equipment are to be used

MOVEMENT OF AIR

Air must be moved through the environmentally controlled poultry house to replenish the oxygen, to remove moisture and ammonia, and to keep an optimum temperature Furthermore, the movement of air in the house must be uniform from top to bottom, and from side to side This calls for special ventilating methods

Fans used to move air Usually, air is brought into the house at the front wall and exhausted by fans installed in the opposite back wall The amount of air to be moved will determine the size and number of fans necessary

Negative pressure system The amount of air exhausted should be slightly more than the amount of air coming into the building This creates a *negative pressure* within the building Sometimes this is known as the *exhaust system* The amount of air to be forced out of the poultry house by the exhaust fans is to be determined by the type, age, and size of the birds and the outside temperature and humidity

When the houses are exceptionally wide, air circulation within the house will not be adequate with the above type of ventilation To remedy this, sometimes the intakes are placed at the front and back of the house, and the air is exhausted through a cupola by fans placed in the center of the ceiling

CALCULATING VENTILATION NEEDS FOR NEGATIVE PRESSURE

In the environmentally controlled poultry house one of the most important considerations in house ventilation is to remove the heat produced by the birds This heat is of two types

(1) *Latent heat*

Latent heat does not increase the house temperature It is that heat given off through expired moisture The percentage and amount vary with the environmental temperature

(2) *Sensible heat*

Sensible heat is that heat given off by the bird through radiation, convection, and conduction, and it does affect the house temperature

Latent and Sensible Heat Affected by Weight of Bird

Not only does the total amount of heat produced per pound (kg) of body weight vary according to the age of the bird, but the ambient temperature at which the bird is living influences it The total heat produced at normal, average temperatures per pound of bird per hour is given in Table 11 7 Heavier birds produce less heat per pound (kg) per hour

Temperature Influences Latent and Sensible Heat

The weight of the bird influences the ratio of sensible heat to latent heat produced by the bird Also, ambient temperature alters the relationship Lowering

TABLE 11 7

WEIGHT OF BIRD AND HEAT PRODUCTION
[At 70°F (21 1°C)]

Bird Weight Lb	Bird Weight Kg	Btu Produced per Hour per Pound of Body Weight	Btu Produced per Hour per Kilo of Body Weight
3	1 36	9 0	4 08
4	1 81	9 0	4 08
5	2 27	8 5	3 86
6	2 72	8 5	3 86
7	3 18	8 0	3 63
8	3 63	8 0	3 63

the air temperature increases the amount of sensible heat It is greater during the day than during the night All these factors have a bearing on the ventilation of poultry houses Table 11 8 gives the details

TABLE 11 8

LATENT AND SENSIBLE HEAT PRODUCED AS INFLUENCED BY AMBIENT TEMPERATURE

Environmental Temperature °F	Environmental Temperature °C	Percent Sensible Heat	Bird Production of Sensible Heat per Hour per Lb Btu	Bird Production of Sensible Heat per Hour per Kg Btu
40	4 4	90	8 1	3 67
60	15 6	80	7 2	3 27
80	26 7	60	5 4	2 45
100	37 8	40	3 6	1 63

Heat Removal from Building

Fifty cu ft of air will remove 1 B t u of heat for each 1°F (0 55°C) rise in temperature Practically, this means that if the house temperature were increased by 5°F (2 8°C) 50 cu ft of air (1 42 cu m) leaving the building would remove 5 Btu of heat Although this is a rough approximation, it is used for determining the number of fans necessary to remove the heat from the poultry house during hot weather

Another Method of Computing Airflow

There is another method used by some to compute the necessary airflow through a chicken house Perhaps it is not quite as accurate as the scientific methods, but probably it is close enough for practical purposes

Rule of thumb Provide 0 012 cu ft of air flow per minute per lb of body weight of the chickens in the house for each 1°F of temperature

Typical examples are as follows·

Air Temperature (°F)	Air Temperature (°C)	Cu ft of Air per Minute per lb of Body Weight (At 30-60% Relative Humidity)
40	4.4	0.48
60	15.6	0.72
80	26.7	0.96
100	37 8	1.20
110	43 3	1.32

Fan capacity must be that necessary for maximum temperature· The total fan capacity of the poultry house should be that necessary to remove the heat from the building when the outside temperature is the highest. There are two methods of lowering the airflow through the house when less air is needed at lower temperatures:

(1) *Rheostats on the fans*
Some are hand operated, and some operate automatically as the house temperature changes. Rheostats are capable of altering the speed of the motors driving the fans.

(2) *Operate only a part of the fans*
As fans must be located at intervals the length of the building, some may be stopped when the air requirement is less. In other instances the fans are installed in banks of 2 or 3 fans placed side by side. Usually one of these—a smaller one—runs continuously, the others cut off one at a time as less air is needed. These latter fans should be run intermittently; e g , 10 minutes on, 5 minutes off.

(3) *Mortality and Airflow*
It is important to note that mortality reduces the number of birds and pounds of birds in the house, thus altering the ventilation requirements

THE AIR INTAKE

The air intake is as important as the air exhaust In the first place, slightly less air must be admitted than exhausted The difference should be about 0 04 in. of static pressure. This will allow the fans to function at almost full capacity and the air to circulate well.

Air Intake Computation

As many types of air intakes are used with modern poultry buildings, it is impossible to give an exact air intake size suitable for all types of construction. But a generalized rule may be made

Rule of thumb Allow 1 sq in (6 45 sq cm) of intake opening for each 4 cfm of air exhaust When light traps are used, increase the intake to 1.25 sq in. (8 1 sq cm)

Shape of air intake opening affects air distribution in house For the air to be distributed well throughout the building, it must enter at a gushing rate, therefore, it should enter the building through some type of narrow

entrance. This is called the *intake slot*. The width of this slot should average about 2 in. when the outside temperature is 70°F (21.1°C). In most instances this will make it necessary for the slot to run almost the length of the house to get adequate air movement.

Adjustable slot intake: Since it is necessary to exhaust more air from the poultry house when temperatures are high and less when they are low, the air intake must be adjusted to maintain 0.04 in. of static pressure within the building. For this reason the slot intake too must be adjustable. This may be accomplished by hand; or a winch and cable system may be used so that the slot can be opened or closed the entire length of the house from a central location. Automatic devices also are available.

Location of the slot intake: In practically all cases, the slot intake should be as high as possible on the wall opposite the fans. Air may be brought directly into the building from the outside, or may enter from the attic, where it will be warmed during cold weather.

Baffle to direct incoming air: An adjustable baffle should be used to direct the amount and direction of the air coming in through the slot from above. At normal temperatures the baffle should be almost horizontal. This will mix the incoming air adequately with that in the house. When more incoming air is needed, the inside of the baffle edge is dropped so as to deflect the air toward the floor.

Velocity of incoming air through the slot: When all details of the ventilating system are operating at average, the velocity of the air coming through the slot will be between 700 and 750 ft (213–228 m) per minute, or about 8.2 miles per hour.

Variations in the air intake: Some poultry houses may be so constructed as to incorporate different locations of exhaust and intake openings. However, the basic principles of the amount of intake and exhaust air still apply.

PRESSURIZED SYSTEM OF VENTILATION

A second, but less popular, method of ventilating the environmentally controlled poultry house is the *pressurized system*. Fans force air into the poultry house, and the outlets are so regulated as to give a slight positive pressure in the building. Usually, the air is distributed through ducts running the length of the house.

Large, Low-speed Fans Used

To make this system work it is necessary to move a large volume of incoming air at a slow rate of flow. Thus the ducts that distribute the air throughout the house must be large. Large, low-speed fans should be used to bring in the air. Such a system reduces drafts in the house, and improves the distribution of air.

Location of Ducts

The ducts should be located about 12 in. (30.5 cm) below the ceiling of the house to induce the best air circulation. In narrow houses they may be placed near the leeward wall; in wide houses they should be placed at the middle of the house, with dampered exits directing the air to both sides.

Installation Difficult

The pressurized system is complicated It corresponds to ventilating a house with forced air In many instances the services of a ventilating engineer should be employed Intricate devices and thermostats will be necessary to govern the speed of the fans used to bring in and circulate the air Air exhausts are just as difficult to install They must be correct as to size, and adjustable, either manually or automatically

Pressurized System More Expensive

Because of the need for ducts and thermostatically controlled fans and exhausts, this system is more expensive—one reason why it has not been adopted on many poultry farms In dry climates it may be necessary to go to added expense to provide dust collectors on the exhausts, as the exhaust air contains a lot of dusty material

COOLING THE POULTRY HOUSE

Forcing more air through an environmentally controlled poultry house when the outside temperature gets above 90°F (32.2°C) is not the solution to providing a comfortable environment for the birds For best results, the air should be cooled

Evaporative Cooling

The only practical and economical way of cooling an environmentally controlled poultry house is by evaporation The principles and recommendations for this method are given in Chapter 5, since the system also is used to cool chick hatcheries

Two systems are used to provide evaporative cooling to the poultry house

(1) *Pressurized system*

With this method, evaporation coolers are placed outside the house and air is sucked through the evaporative pads of the cooler, then forced into the poultry house Openings are provided through which the air is exhausted from the house A slight pressure is built up in the building

(2) *Pad and fan system*

This is a different variation of evaporative cooling, used only in poultry buildings The evaporator pad is placed in the wall at one end of the poultry house, and exhaust fans at the other The exhaust fans cause air to be sucked through the evaporator pad, thus reducing the temperature of the incoming air The principles and amount of cooling are the same as those involved with the evaporator-cooler

Pad and Fan Specifications

Unless the house is over 200 ft (61 m) long, the pad may be placed in one end of the house, the fans in the other In the case of longer houses pads may be placed in both ends of the house and the exhaust fans in the center, or the pad in the center and the fans at each end

Description of pad The pad should be placed on the windward wall of the house It should be about 4 ft (1 22 m) high and long enough to allow the required amount of air to enter The pad should be made of excelsior or

some similar material. A narrow trough should be constructed just above the pad. Holes should be drilled in the trough to allow a uniform flow of water over the pad. At the bottom of the pad another trough is placed to collect excess water running off the pad, the excess running into a tank. A water pump is placed in the tank and the water is recirculated to the top trough. Water flows into the tank through an incoming water line. A float valve is placed in the tank to govern the amount of water flowing into the tank through the pipe, thus maintaining a uniform level of water in the tank.

Another innovation: Pads about 18 in. (45.7 cm) wide may be placed horizontally in a hood outside the house, running the entire length. The pad is kept wet by foggers placed just above it. Air is drawn directly into the house through the wet pad and hood.

Description of exhaust fans: At the end of the house farthest from the evaporator-pad, exhaust fans should be located in the opposite wall or in the end wall. One or more fans will be required to move a specified amount of air, depending on the number of birds in the house and the length of the house. Fans that revolve slowly, yet move large volumes of air, should be used.

Exhaust Fan Requirement for Pad and Fan Cooling

The amount of air to be moved through the poultry house having pad and fan cooling will depend on:

(1) age of the birds;
(2) number of birds;
(3) weight of birds;
(4) distance from pad to exhaust fan or fans;
(5) type of building insulation;
(6) maximum outside temperature.

Houses with this method of cooling require the movement of more air through them than houses with only air circulation. The required amount of air to be moved through the house will vary from 1.4 to 2.0 c.f.m. per pound of bird in the house, the exact amount depending on the type of bird, house insulation, length of house, outside temperature, etc.

Rule of thumb: Provide 1.75 cfm of exhausted air per pound of live birds in the house.

Example: A house holding 4,000 Leghorn laying pullets, weighing 4 lb each, represents 16,000 lb. At the rate of 1.75 cfm per pound, 28,000 cfm of air would need to be exhausted. This would be equivalent to 7 cfm per bird.

Heat buildup within building: When the cool air comes in at one end of the building, flows over the birds, then out the other end, the heat of the birds warms the air as it flows through the house. This buildup should not be greater than 5°F (2.8°C). If it is greater, more air should be made to pass through the house by increasing the speed at which the air flows.

Pad Requirement for Pad and Fan Cooling

The air should come through the pad at about 150 ft (45.7 m) per minute. To calculate the area of the pad, take the amount of air moved per minute by the exhaust fans at 0.1-in. of static pressure and divide by 150.

Example 4,000 Leghorn hens weighing 4 lb each require 28,000 cfm of air Divide 28,000 by 150, giving 187 sq ft of pad area If the pad were 4 ft high, it would have to be approximately 47 ft long

Remember The air to be exhausted must first be accurately calculated, then the pad area computed

Wet Pad Not Used at All Times

Pad and fan cooling is not used at all hours, day and night, but only during hot hours When the water going to the pad is shut off, the ventilating fans continue to run to keep air moving through the house When the pad is dry, the ventilating system becomes a conventional one except for the fact that there is a very long distance from the entrance of air to the exit, therefore a faster air movement is necessary

Thermostats required Water flowing to the pad may be turned off and on thermostatically or manually The exhaust fans may be operated similarly

Thermostat on water pump The thermostat should be set at 80°F (26 7°C) When the temperature in the house reaches this point the pump starts, when it drops below 80°F (26 7°C), the pump stops

Thermostats on fans With most installations, two or more exhaust fans will be required Several small fans are better than one large one There should be a thermostat on each fan, but the temperature at which the fans start and stop should be varied All fans should be operating when the house temperature reaches 80°F (26 7°C)

Pad and fan assembly kits available Several manufacturers produce the materials necessary to install pad and fan cooling equipment The items included are the pads, troughs, water pump, floats, and thermostats This makes it easy to construct the system Exhaust fans and thermostats also are available from many manufacturers and distributors

LIGHT CONTROL IN THE ENVIRONMENTALLY CONTROLLED HOUSE

Although the use of light in the poultry house is discussed in Chapter 17, the environmentally controlled house must be lightproof, that is, no outside light should be allowed to enter the building Where fans are installed in the side, light seeps through the fan opening For this reason a *light trap* must be installed This is accomplished by constructing a hood on the outside of the building over the fan opening It should extend down far enough to prevent light from entering, yet not impair the movement of the air

STANDBY ELECTRIC PLANTS NECESSARY

Probably the most important part of operating an environmentally controlled poultry house is a constant flow of air through it Although the amount of electricity used is not great, an uninterrupted source is a must, for when the fans stop, the supply of oxygen is cut off, and heat builds up to drastic proportions No environmentally controlled poultry house should be constructed without a standby electric plant

Automatic changeover required The devices necessary to change the source of electricity from conventional to standby should work automatically. An alarm system to alert the caretaker to make the changeover is not adequate. However, an alarm should be used to notify the poultryman that the regular source of electricity has ceased and that the standby plant is in operation.

Poultry House Equipment

Good equipment is a requisite of good poultry management Most equipment that was modern a few years ago probably is now out of date, impractical, and uneconomical Today, there is more demand for automation in the poultry house to lower the hours of labor required to care for the birds and to reduce the labor costs

This chapter deals with equipment for houses in which the birds are kept on the floor Chapter 17 deals with cages and cage management

BROODING EQUIPMENT

The so-called brooding age of the chicken refers to the first five to six weeks of life Chicks are small during this stage, and require equipment that is small in size and not fully automated Supplementary heat also is needed

The Brooder House

Until recently the accepted practice among poultrymen was to brood the chicks in a separate *brooder house*, keeping them there until they were eight to ten weeks of age when they were transferred to a *growing house* Now, however, separate houses are seldom used, chicks are kept in the same house from the first day until near the time they reach sexual maturity

Brood grow lay system In many instances the birds remain in the same house throughout their lives—from the first day until the end of their laying year Thus, the house becomes a brooding house with supplemental brooding heat, a growing house, and a laying house with nests Therefore, much of the equipment in this type of house must accommodate birds of various ages

Fuel Supply

The requirement for brooding heat may be met with a variety of fuels Almost any available product may be used to furnish the fuel, and heating devices have been manufactured to use the one selected These fuels are

Gas Gas may be secured in two forms

(1) Natural gas Btu rating of about 1020 to 1030 per cu ft

(2) Liquefied petroleum two types are available

(a) Propane Btu rating of about 2537 per cu ft

(b) Butane Btu rating of about 3261 per cu ft

Gas may be used for heating individual brooders or central heating units

Kerosene This fuel is used for heating individual stoves or central heating installations

Coal Anthracite rather than bituminous coal is used for brooder stove fuel where it is available It burns with a minimum of volatile matter and smoke

Oil Fuel oil is commonly used in some sections of the world to heat brooder stoves or central heating systems

Electricity: Electricity is used as the fuel supply for a variety of brooder heating devices, such as heating rings, electric light bulbs, infrared light bulbs, etc.

Method of Supplying Brooder Heat

Chick brooders are units which furnish the heat necessary to keep the birds warm. Usually some provision is incorporated that will deflect the heat downward toward the chicks. There are many types of brooders.

Hover-type: This represents the most important and most common type of brooder. The heat unit is covered with a round or angular piece of metal to deflect the heat downward.

Suspension used for support: The brooder unit is suspended from the ceiling by a cord or cable in such a manner that the brooder may be raised or lowered. When not in use it is drawn as high as possible, out of the way, and left there until it is needed for the next group of chicks; or it may be moved from the house.

There are several methods of heating the hover-type brooder and these give rise to their classification.

Conventional: Conventional hovers are 6 or 8 ft (1.8 or 2.4 m) indiameter with the gas burner located in the top of the dome. By changing the gas jets they operate on either natural or LP (liquefied petroleum) gas. They accommodate from 500 to 750 day-old chicks, and have an input rating of 12,000 to 20,000 Btu per hour depending on their size.

Flat-type: This hover utilizes a "pancake-type" canopy and a specialized burner that produces radiant heat. The canopy (hover) is almost flat and much narrower in diameter, seldom exceeding 4 ft (1.2 m). It should be about 24 in. (61 cm) above the floor; 500 chicks usually are placed under each brooder. The Btu input capacity varies from 25,000 to 50,000 per hour. Radiant heat cannot be measured with a thermometer. Only the comfort of the chicks can be used as an indicator of correct supplementary heat.

Flameless: There is a flameless gas burner unit in which a catalyst is employed to produce a chemical reaction and heat production. No hover is used, the heat being deflected from the "burner." It has a Btu input rating of about 22,000 per hour.

Infrared: These are heated with a special burner under a special tile refractory that produces infrared rays when heated. There are several types of these brooders. Some employ a canopy; others do not. The Btu input is relatively low.

Conventional kerosene: A special burner, using kerosene as the fuel, and covered with a large canopy, is used in many areas where other fuels are not available.

Conventional electric: Where electric power is inexpensive, electricity may be used as a source of brooder heat. Electric heaters are placed under a canopy, with a thermostat to turn the electricity on and off. In some models a small electric fan is placed in the top of the canopy cone. It draws fresh air from outside at the top, and circulates it over chicks on the floor.

Infrared heat bulbs Regular infrared heat bulbs may be used to furnish heat to the young chicks They usually are mounted in groups of four bulbs that are thermostatically controlled

Slab heating Rather than supply heat from above the chicks it is possible to furnish the heat from below In this method a concrete slab (floor) is heated by running pipes through the concrete and forcing warm water through the pipes A thermostatically controlled boiler is located at one end of the house In some instances the slab is heated with electric wires imbedded in the concrete

Caution Do not heat the entire floor of the brooder house, heat only a section from 6 to 8 ft (1 8–2 4 m) wide in the center and extending the entire length of the house Chicks feather poorly if all the floor is heated

Hot water brooders Hot water pipes are placed about 12 in (30 cm) above the floor to furnish the heat supply A boiler at one end of the house heats the water in the pipes A thermostat is placed on the boiler to turn the burner on and off and to maintain a constant water temperature in the boiler An additional thermostat is placed under the pipes in the center of the house This operates a pump at the location of the incoming water line at the boiler so that when the brooding temperature drops, hot water is forced through the pipes by the pump until the brooding temperature reaches a desired figure

From 4 to 8 hot water pipes are placed down the center of the house and a cover is placed over them to hold the heat near the floor

Important Never place the water pipes near the back or front wall of the house, they should be in the middle to provide ample ventilation under the cover

Room heating When environmentally controlled houses are used for brooding chicks it is possible to heat the entire house to furnish an ample brooding temperature Normally, this temperature is lower than that necessary under a canopy type (or similar) brooder Room heating requires a floor temperature of about 85°F (29 4°C) for starting chicks This method of furnishing heat is quite popular with broiler producers having a closed house

Heat necessary to warm the entire house may be supplied by a central heater, then forced throughout the house through a duct Another method is to suspend regular brooder stoves about 6 ft (1 8 m) above the floor and use them to heat the entire room

Attraction Lights

Training day-old chicks to go to the heat supply when they are cool is difficult To teach them the location of the brooder heat, a small light may be placed under the canopy or at the location of the heat This light may be supplied by one 7½ watt white light bulb for each brooder stove or equivalent area After 2 or 3 days the chicks will learn the heat source and the light may be turned off

Brooder Guards

Some material must be placed around the brooder stoves to prevent the chicks from straying too far away from the heat supply until they learn the source of

heat. These are called *brooder guards* and circle the brooder heat area at a distance of about 30 in. (76 cm). As the chicks grow older the area inside the *ring* is increased to give the birds more room. The material used for the brooder guards may be solid or wire mesh. Solid is preferred during cold weather; wire mesh, during hot weather.

Solid guards may be constructed of some flexible material such as Masonite. Strips from 16 to 24 in. (40-61 cm) wide are placed around the brooder stove and the sections held together with large "clothespins." Corrugated cardboard also may be used, but as it cannot be washed and cleaned it must be discarded after the guards are no longer needed.

Waterers for Young Chicks

Waterers for young chicks are confined almost entirely to the pan-and-jar type. Since water must be easily accessible, several *small founts* must be placed around each brooder stove, inside the brooder guard. The pan-and-jar waterer is the most practical. There are several innovations: (1) jar and pan, (2) plastic, (3) all glass, (4) metal, and (5) plastic and metal. Each fount should hold approximately 1 gal (3.8 liters) of water. Several small founts are better than a few large ones.

Waterers After One Week of Age.—As soon as the chicks learn to drink, and the brooder guards are expanded or removed, larger waterers should be substituted. Most of these are of a type that can be used until the birds reach sexual maturity; some may be used for laying birds as well. These waterers and watering systems usually are automatic. There are many types:

8-ft (2.4 m) automatic troughs: The trough is usually "V"-shaped, and adjustable for height from 2 in. (5.1 cm) to about 16 in. (40.6 cm) above the floor, and 8 ft (2.4 m) in length. There are three types, the differentiation being in the type of valve used to turn the water on and off.

(1) *Suspension valve:* One end of the trough is suspended from the frame, the other hangs on a valve. The weight of the water in the trough turns the water on and off.

(2) *Float valve:* The trough is mounted solid to the frame. At one end of the trough is an enclosed pan in which there is a float valve that operates according to the height of the water in the pan and the trough.

(3) *Electric valve:* An electric valve governs the flow of water to the trough.

Hanging waterers: These are round waterers constructed of plastic or metal that hang from the ceiling. A bell-shaped dome encloses a valve to maintain a designated level of water in the circular pan. They may be raised or lowered by changing the length of the suspension cord, cable, or chain.

Cup waterers: Cup waterers are small drinking cups, from 2 to 6 in. (5.1-15.2 cm) in diameter, and from 1 to 3 in. (2.5-7.6 cm) deep. They may be classified according to the manner in which water is admitted to them.

Suspension-type: A relatively large cup is attached to the end of a vertical pipe or hose. Made a part of the cup is a valve that opens and closes according to the weight of the water in the cup.

Trigger-type: Usually these cups are clamped onto the top of a horizontal

pipe running the length of the chicken house. A valve is situated in the bottom of the cup with a "trigger" that opens and closes the intake valve. The "trigger" is operated by the bird. Cups on this type of waterer are quite small. The horizontal pipe may be raised or lowered by cables and a winch; thus the height of all of the cups may be altered at one time according to the age of the birds.

Note To operate cup waterers a pressure equalizer must be installed in the incoming water line.

First Feeders

So that the chicks learn to eat at an early age, a large area of feed must be supplied the first few days. Usually the first feed is spread over a large, flat container with a shallow edge 1 or 2 in. (2 5-5.1 cm) in height. Such a container may be supplied through one of the following:

(1) Chick box lids
(2) Feeder lids: These are the same size as chick box lids but manufactured especially for this purpose.
(3) Plastic feeders: They are similar in size to chick box lids but are made of plastic or some similar material. They may be washed and reused, an advantage.

Second Feeders

When the chicks are five days of age the feeder lids are no longer practical; larger feeders must be substituted. In most instances these new feed containers should be large enough to handle the birds until they are fully grown. Some are automatic, some must be filled by hand. There are several types·

Trough feeders Troughs that are 4 to 6 ft (1 2-1.8 m) in length are filled by hand A grill or reel over the trough will help prevent feed wastage and keep the birds out of the troughs.

Tube feeders These are large tubes about 8 to 16 in. (20.3-40.6 cm) in diameter and about 2 ft (0.6 m) long. At the bottom a large pan is suspended into which the feed flows from the tube, and from which the birds eat. Tube feeders usually are suspended from the ceiling.

Automatic feeders Automatic feeders consist of a pan or trough from which the birds may eat, and of some mechanism for automatically transferring feed from a central hopper to the pans or troughs. There are many types, but the main classifications are.

Trough and chain A continuous trough goes around the poultry house and a special chain with cross-cleats drags the feed the length of the trough A hopper at one end of the house or pen acts as a reservoir for the feed

Conveyor-and-pan system An auger or chain pushes feed through a tube or trough. Openings are made at intervals in the tube so that the feed drops out into circular pans Some automatic method is employed to stop the flow of feed once the pans are full.

Shaker system The trough, supported on rollers, shakes back and forth. This causes the feed to move down the trough. An advantage of this

system is that one straight trough may be used; the trough does not have to circle the inside of the house.

Conveyor system: Pans or tube feeders are hung from a conveyor chain that makes a circle down and back through the house. As the pans go by the central feed hopper, they are filled by hand or semiautomatically.

Tube and trough system: Feed is moved along a tube which has a feed trough attached to it. Holes in the tube allow the feed to be pushed into the trough at the bottom.

Tube and tube feeder: An auger or cable with discs forces feed around the house through a tube. Other tubes are attached to the main tube at regular intervals. Through these smaller tubes the feed drops into hanging feeders.

Type of feeder and age of birds: The "second feeder" must be of a size and type that will be satisfactory for chicks as young as one week of age. If the trough is too large it will be necessary to use another feeder between the time the feeder lids are removed and the growing feeders are used. This will increase the investment in equipment.

Feeder Time Clocks

Rather than operate the automatic feeding equipment continuously, it may be connected with a time clock that runs the feed-moving mechanism intermittently. Time clocks are used to start and stop the equipment. This procedure lengthens the life of the feeding equipment, particularly the tubes and troughs.

Artificial Light

Regardless of the type of poultry house, some method of providing artificial illumination will be necessary. The amount and type of lighting is a detailed subject, and is covered fully in Chapter 18.

Carrier

In many instances a *carrier* in the poultry house will facilitate the movement of equipment and other items throughout the length of the poultry house. Such a carrier will consist of a track on which a platform is suspended. Correct placement of the carrier track in the house will be determined by the jobs for which it is to be used. In the brood-grow-lay house it should be located near the nests so that it may be used to transfer eggs.

Bulk Feed Tank

Bulk feed has replaced bagged feed in most commercial poultry areas of the world. As a reservoir for feed, tanks are set next to the poultry building. Their size should not be governed by the feed consumption of young chicks, but rather by the amount eaten by the oldest birds the house will contain. Each tank should hold one week's supply of feed, plus about two days' reserve.

Feed Scales

Most modern methods of feeding chickens involve weighing the feed consumed each day. Many programs call for weighing the daily feed allocation. These requirements necessitate scales that are accurate and practical. Some scales are automatic; some, semiautomatic.

GROWING EQUIPMENT

Most of the equipment used during the bird's growing period will be the same as that provided during the laying period Careful selection of equipment should be made to make certain that as little as possible of the equipment will be duplicated There are, however, several items used for growing birds that should be discussed Types of floor material are also of interest

Type of Floor

There are several types of floors used in poultry houses Many times the type used for the laying birds will determine the one used during the growing phase

All litter floor With this system the entire floor is covered with litter The floor may be either dirt or concrete, depending on the type of poultry enterprise involved, and the substance of the soil in the area See Chapter 11

Slats and litter This house is constructed so that a part of the floor area is covered with slats Although built primarily for those birds producing eggs, particularly breeder birds producing hatching eggs, growing birds must be trained to use the slats when they are young, thus they become a part of the growing equipment In some instances wire is substituted for slats, but *wire is a poor substitute*

Amount of slats (or wire) Slats should cover about 60% of the floor area, 40% should be covered with litter Although an all slat floor may be used for commercial laying birds and egg type breeders, meat type breeders mate better if some littered area is available Fertility may be reduced when the breeders are kept on an all slat or all wire floor

Slat size and spacing Slats should be about 0 5 in (1 25 cm) to 2 in (5 1 cm) wide and spaced about 1 in (2 54 cm) apart, and run length wise of the building *Do not* run them crosswise of the house because birds cannot brace themselves to eat from the feeders

Wire size When wire is to be used *in place of slats, extreme care should be* used in construction The wire should be heavy enough not to sag This will call for supports about every 12 in (30 5 cm) Welded wire fabric should be used to provide greater support It should have a mesh size of 1 in (2 54 cm) by 2 in (5 1 cm), with the long part of the mesh running crosswise of the building

Constructing the slats (or wire) Slat or wire floors should be constructed in sections so that they may be removed when it is necessary to clean the droppings from under them, or when the house is cleaned

Location of the slats (or wire) The slats may be located in the house in two ways

(1) *Down the edges of the house* One-half of the slats are placed against the front wall, and one-half against the back wall This has an advantage in open sided houses as any driving rain falls on the slats rather than on the litter Furthermore, all chores may be handled from the central littered area

(2) *Down the center of the house* This system leaves one-half the littered area at the front of the house and one-half at the back, with the

slats in the center. This construction has some advantages in the environmentally controlled house, because the feeders and waterers which are placed on the slats are closer together. With the open-sided house, there are disadvantages because rains blow in and wet the litter, and it is difficult for a man to cross over the slats to get to the opposite side of the house.

Height of the slats: The top of the slats should be 27 in. (68.6 cm.) above the floor. This will allow enough space below the slats for a year's droppings to accumulate.

Wire mesh should be used on the sides of the slat supports to provide more air movement across the droppings in an endeavor to keep them dry. When slats are placed against the outside wall of an open-sided house it will be necessary to construct a movable curtain or cover for the area below the slats to keep air from blowing through during cold weather.

All-slat House

Commercial laying birds may be kept on an all-slat floor. The advantage is that it requires less floor space per bird than when the birds are kept on a littered floor. On litter, commercial laying pullets will require about 2 sq ft (0.18 sq m) of floor space per bird. When they are kept on an all-slat floor, 1 sq ft (0.09 sq m) is ample. The requirement for constructing the slats, their size, and spacing are the same as for the slats used for the slat-and-litter combination. *Meat-type breeding birds should not be kept on an all-slat or on an all-wire floor* but egg-type breeders may.

Deep-pit House

Popular of late is a house with an all-slat floor constructed above a pit into which the droppings fall. The pit should be about 7 ft (2.1 m) high, allowing enough space for an attendant to walk in, or in which a skiploader may be used for cleaning. The "pit" should be constructed above the ground if the building is to be environmentally controlled. In such buildings air is exhausted from the building at a point just below the slats. Intake slots are located near the upper eaves, the same as with the ordinary environmentally controlled building. If the house has natural ventilation (open sided) the pit may be constructed below the ground surface, but difficulty usually is encountered in removing the droppings unless a convenient door is provided at one point. The pit into which the droppings fall must not allow water seepage from the outside.

Sloping Wire Floor

An innovation for the use of a wire floor in a poultry house is known as the *sloping wire floor.* The floor is sloped at the rate of 1½ in. (3.8 cm) per running foot (30.5 cm). Eggs will roll on wire with such a slope, and the floor is constructed so that any eggs laid on the wire will find their way to a collection compartment at the bottom of the slope. But nests should be provided as the main area in which eggs are laid; the sloping wire offers only a means of collecting "floor eggs."

There are two methods of constructing the wire floors:

(1) *"A"-shape:* The top of the floor is in the center of the house, with the

wire sloping both ways to the walls Nests are placed against the walls or against an alley next to each wall

(2) *"V"-shape* The highest part of the floor is at the junction with the front and back walls of the house The floor slopes toward the center where the nests are located In some instances a movable belt collects the eggs from the nesting area and the compartment into which the "floor eggs" roll

Type of wire used for floor The welded wire fabric used for the floor should be 14 gauge In some instances the bottom wires could be 12½-gauge and the upper wires, 14-gauge This gives additional support, so important with any type of wire floor The mesh size should be 1 in (2 5 cm) by 2 in (5 1 cm) or on occasion, 1 in by 1 in (2 5 × 2 5 cm) Breeder males will show a lower incidence of sore feet when the smaller mesh size is used The welded wire fabric should be laid so that the wires uppermost run crosswise of the house, enabling the eggs to roll more easily

Waterers

Most watering systems manufactured today are suitable for growing birds and for those that are producing eggs However, any system that uses a deep pan or trough will not be satisfactory for young or small growing birds because the chickens cannot reach the water This is particularly true of the arrangement using a pan and float valve and any other watering system using a deep trough Long waterer troughs through which water runs continuously also are not satisfactory for young chicks, but are for growing birds and layers

Feeders for Growing Birds

In many instances the same feeder may be used for both growing and laying birds This is particularly true of most automatic feeders But some systems pose a problem Many times the trough or pan used for growing birds is too small for adult birds, and a larger one must be substituted In choosing feeding equipment care should be taken to select a type that may be used for growing and laying birds

Specialized Feeders for Controlled Feeding—It is becoming commonplace to restrict the feed intake of growing birds In some instances this is difficult with automatic feeding equipment, as the feeders run empty for a time in order to reduce the bird's feed intake When the feeder kicks on, and fresh feed starts to flow through the system, the birds near the feed reservoir get the first feed and eat longer than those at the end of the house The difficulty is further complicated when there are several pens in the house

To alleviate this problem, some manufacturers of automatic feeding equipment have an arrangement whereby feed flows through the tube until it is completely filled, and feed drops into pans in all sections of the house at the same time, therefore, all birds have an equal period of feed consumption

Other Special Feeders—Tube type feeders are used for feeding cockerels when males are kept with the females, during either the growing or the laying period These feeders are filled by hand and are kept at a height so that males may eat from them, but not the females They are known as *cockerel feeders*

Other similar feeders are used for oyster shell or grit, and are known as *shell and*

grit feeders. They are hung at a low level to enable both males and females to eat from them.

Roosts

As a general rule, roosts are not needed in a poultry house, either for growing or laying birds. On occasion, however, where an all-litter floor is used, *social order roosts* are provided for the males when they are kept with females. About 2 in. (5.1 cm) of roosting space is provided for each male in the pen. They should be constructed on "horses" that may be moved about the pens. Such roosts are of value when males fight; the timid ones can jump on the roost to get away from the trouble.

LAYING HOUSE EQUIPMENT

In general, the feeding and watering equipment used for the growing birds should be ample when they are producing eggs. This is particularly true in the brood-grow-lay house. But there will be some equipment pertinent to laying birds only, such as:

Nests

Many types of nests have been used for chickens such as:

- individual;
- colony;
- multiple-bird;
- room-type.

Individual nest most common today: These nests are comprised of individual compartments in which the hens lay. There are many types manufactured. Individual nests are constructed in batteries about 5 nests in length. The batteries may be 1, 2, or 3 tiers high.

Size of the nest: Each nest is about 12 in. (30.5 cm) wide, 12 in. (30.5 cm) high, and 12 to 14 in. (30.5-35.6 cm) deep. Slightly larger nests are used for meat-type layers than for egg-type producers. A front, lower lip about 3 to 4 in. (7.6-10.2 cm) in height is used to help retain the nesting material.

Shape of front opening: Most nests are constructed with a square front opening, although research has shown that an opening shaped similar to a triangle with an apex at the bottom, and the bottom rounded, will cause the birds to use them more.

Sloping roof: The roof of the top section should slope to keep the birds from roosting on the nests. If a sloping roof is not available, some other method must be employed to prevent roosting.

Perches necessary: So the birds may gain access to the nests, perches should be a part of the nest section. The perches should be hinged so that they may be raised to "close" the nests, thus preventing birds from entering.

Removable bottoms: Bottoms that are removable facilitate cleaning.

Ventilation in nests: Often the nest becomes the hottest place in the chicken house, particularly when the sides and back are not ventilated.

There must be adequate air movement through the nests A back con structed of wire mesh may be the best, but many have open backs

Roll away nests These are single section or colony nests with a sloping wire floor The birds enter from one side and because of the sloping floor the eggs roll to a container at the back, away from the actual nest Eggs are gathered from the container

Automatic Egg Pickup System

The roll away nest may be equipped with an automatic egg pickup Instead of rolling into a container at the back of the nest the eggs roll onto a narrow, movable belt The belt runs the length of the house behind the nests, and brings the eggs to a separate receiving room at the end of the building Two rows of roll-away nests usually are placed back to back, thus requiring only one belt There must be one belt for each tier of nests Special machinery and belts are available from manufacturers

Artificial Illumination

The use of artificial light in the laying house is mandatory This is true not only in the environmentally controlled poultry house, but in open sided houses, be cause it is necessary to increase the length of the light day during the months when hours of natural daylight are less than adequate to sustain normal egg pro duction See Chapter 18 for complete details

Broody Coops

It is the natural inclination for laying hens to go "broody" after they lay their first clutch of eggs Broodiness is an inherited characteristic, more pronounced in meat type breeds than egg type birds A broody hen may be returned to her normal condition if she is placed in a coop with a wire or slat floor Such broody coops were a necessity years ago However, the broody factor has been almost eliminated in most strains of chickens through genetic selection and modern breeding methods, and because of this broody coops are no longer used

Room Size

In some instances chickens do better when confined with relatively few birds to a unit This is particularly true of breeding birds Therefore, the construction of pens in the poultry house will be necessary Wire used for the fences that divide the house into pens should be heavy-gauge, preferably welded wire fabric, 1 in by 1 in (2 5 cm) or 1 in by 2 in (2 5 X 5 1 cm) The pen dividers should be re movable to facilitate cleaning the house

Doors between pens Placement of the doors between the pens should in volve some study They should

(1) swing both ways, making it easier to push equipment through,
(2) have the bottom 12 in (30 5 cm) above the floor so they will swing above the litter,
(3) be located in the path of the carrier if one is used,
(4) close securely when not in use to prevent birds from going from pen to pen,
(5) be removable when the house is to be cleaned

MANURE DISPOSAL EQUIPMENT

There are many methods of removing chicken manure from the poultry house. Some involve mechanical equipment; others are a part of specialized systems for disposal and are discussed in Chapter 44.

Manure-Collecting System

When birds of any age are raised on slats or wire, or a portion of the poultry house floor is covered with slats or wire, large quantities of droppings accumulate below them. This manure may be allowed to remain until the birds are removed from the house, when it is removed. The manure may be collected regularly by specialized collecting equipment. Removal of droppings from cage operations is discussed in Chapter 17.

Collecting equipment: One method of removing the manure from under slats or wire while the birds are in the house is by the use of a *drag*. At the time the house is constructed, a concrete pit is built under the slats or wire. A steel, motorized drag is used to remove the droppings from the pit. The drag is made to go back-and-forth over the droppings several times until the area is clean. Droppings are collected at the end of the house and usually augered into a truck and hauled away; or they may be allowed to run into a *lagoon*, one method of specialized disposal. The equipment necessary to the drag system is available from several manufacturers.

Litter Removal Equipment

Although it is difficult to remove litter from the house when there are chickens in it, except by manual methods, special equipment may be used when the house is vacant. Many types of machinery are in use:

skip loader;
vacuum;
belt and loader.

ELECTRICITY ON THE POULTRY FARM

The present demand for electricity on the poultry farm is great. Automation has increased the use of electrical equipment, and environmentally controlled housing has increased the need for artificial illumination. In many instances special control panels and heavier wiring will be necessary. Some electrical terms and requirements are given below to provide a better understanding of the factors involved with electricity on the farm.

Definitions

Alternating current: Alternating current (AC) is current which reverses direction rapidly and regularly. In AC, any one wire is first positive, then negative, then positive, etc. The cycle is completed 50 or 60 times every second, with usual electric power, thus giving rise to 50-cycle or 60-cycle terms for current. Electric motors must match the cycle involved.

Ampere: The unit of measurement of electric current is the ampere. It is the rate at which current is caused to flow through a resistance of 1 ohm by a pressure of 1 volt.

Current Current is the flow of electricity in a circuit Current is measured in amperes

Direct current Direct current (DC) is current that flows in one direction only One wire is always positive, the other, negative

K V A Abbreviation for kilovolt amperes, the product of volts times amperes, divided by 1000

K W Abbreviation for kilowatt, the unit of measurement of electric power A kilowatt (K W) equals 1000 watts It is the product of volts times amperes, divided by 1000

Kilowatt hour The amount of electric power represented by 1000 watts for 1 hour

Ohm The ohm is the amount of resistance that will permit current to flow at the rate of 1 ampere under a pressure of 1 volt

Single phase A single phase, alternating-current system is one having a single voltage in which the reversals of that voltage occur at the same time and are of the same alternating polarity throughout the system

Three phase A three phase alternating current system has three single phase circuits (or groups of circuits), each so timed that the alternations of the first are 1/3 cycle (120°) ahead of those of the second and 2/3 cycle (240°) ahead of those of the third

Voltage Voltage is the force, pressure, or electromotive force (EMF) which causes electric current to flow in an electric circuit Its unit of measurement is the *volt,* which represents the amount of electric pressure that will cause current to flow at the rate of 1 ampere through a resistance of 1 ohm

Watt The watt is the unit of measurement of electric power, 746 watts is equivalent to 1 horsepower The watt represents the rate at which power is expended when a pressure of 1 volt causes current to flow at the rate of 1 ampere

TABLE 12 1

RUNNING CURRENT REQUIREMENTS OF ELECTRIC MOTORS

Motor Horse-power	115 volt 1 phase AC		230 volt 1 phase AC		230 volt 3 phase AC	
	Current Load(1) Amp	Wire Size(2) Gauge	Current Load(1) Amp	Wire Size(2) Gauge	Current Load(1) Amp	Wire Size(2) Gauge
1/6	4 4	14	2 2	14		
1/4	5 8	14	2 9	14		
1/3	7 2	14	3 6	14		
1/2	9 8	14	4 9	14	2 0	14
3/4	13 8	12	6 9	14	2 8	14
1	16 0	12	8 0	14	3 5	14
1 1/2	20 0	10	10 0	14	5 0	14
2	24 0	10	12 0	14	6 5	14
3	34 0	6	17 0	10	9 0	12
5	56 0	4	28 0	8	15 0	10

Source *National Electric Code*
(1) Full rated load current in amperes (starting load much higher)
(2) Minimum wire size Larger sizes required when there is a voltage drop in the line

TABLE 12.2

RELATIONSHIP BETWEEN WIRE SIZE, ELECTRICAL LOAD, AND FUSE SIZE

Wire Gauge Size	Maximum Watts		Fuse or Breaker Amps.
	at 120 V	at 240 V	
14	1725	3450	15
12	2300	4600	20
10	3450	6900	30
8	4600	9200	40
6	6325	12750	55
4	8050	16100	70
2	10925	21850	95
0	14375	28750	125

Current Requirements of Motors

Motors are rated by horsepower (hp). The ampere and wire requirements for motors of different sizes are given in Table 12.1.

Wire Size and Electric Load

The relationship between wire size, electric load, and fuse size is shown in Table 12.2.

Brooding Management

It takes more than good chicks, good feed, and good housing to operate a commercial poultry farm Although these represent the foundations on which a profitable enterprise is built, MANAGEMENT has a very great deal to do with how well or how poorly the business does The farm manager who is an expert in his field and has the ability to get the most from his operation, is the one who succeeds Management, in itself, is composed of a "lot of little things," many of which seem unimportant, but when all are put together, lead to efficient production and greater profits Some say that poultry farm managers are "born," rather than trained, that some just have the ability and sensitivity to make good poultrymen Obviously something of this nature must be true, for many can do the job, while others cannot But perhaps good management is only the ability to detect the little things, to be able to see trouble before it happens, and to know when to alter any of the many programs involved with handling chickens Certainly this ability is a great asset, but "know how" is important too Poultry production is a science that encompasses many facets, practices within the industry are changing every day The poultryman who understands the basics of poultry production and who knows "how to do things," then puts his knowledge and his "green thumb" to work to accomplish the best results, is the poultryman who will have a worthwhile enterprise

This chapter deals with management factors having to do with the brooding period, usually defined as the first five or six weeks of a chick's life Floor management only is discussed here, cage management is treated in Chapter 17 Broiler management is covered in Chapter 20

Cost Management

Too frequently the subject of management has covered only those factors necessary to do a better job increased egg production, better growth, lower mortality, etc , are examples But today's management program must revolve around *cost management*—the ability not only to do a job well, but to do it profitably Production costs are becoming more and more important in this business, where unit profit is small The fact that the poultry farmer has little to do with the price for which he sells his product, price being the result of supply and demand, only emphasizes the importance of being able to furnish the product at the lowest cost Thus, good management must always involve financial management, the ability to reduce costs to their limit

The Management Program

Good poultry farm management must be built around a definite program, every part must be planned in advance It should be written out, and include

(1) Who does what and when

Everyone connected with the project should know his duties, and when they are to be finalized First, the program must be detailed, if the chicks are to be debeaked at seven days of age, a calendar date must be shown Every "chore" must be itemized, and a date set

(2) Whose feed, and what type will be used

Many poultry enterprises are so large today that more than one brand of feed will be used. Feed comes in different forms: mash, crumbles, and pellets. The feed must be given careful consideration when the management program is discussed. In other instances, however, the farmer is a contract grower, and he uses only the feed furnished him.

(3) Vaccination schedule is very important

The vaccination program is to be studied carefully, and the manufacturer as well as the type of vaccine and the age at which it is to be given must be incorporated into the written program. Who is responsible for carrying out the details must be made perfectly clear.

(4) Have a goal

The good farm manager will discuss costs with his employees (or with himself). What is the goal for the cost of feed necessary to raise a pullet, the cost of feed per dozen eggs, the cost of medication, the cost of labor, etc., and finally, the total cost to complete the production of the product involved. Just to raise 90% of the pullets to 23 weeks of age is not enough. At what cost must they be raised is more important.

THE BROODER HOUSE

Production of a good pullet is one of the most important parts of good management, for how well the pullet is grown will greatly determine how well she produces in the laying house. Similarly, the growing of a good male will exert an influence on his behavior in the breeding pen. Good growing starts with good brooding; adequate housing plays an important part during this period also. The details for a proper house are given in Chapter 11, but there are other items of importance too.

Types of Chickens and Management Recommendations

Size and type of chicken cause variations in the recommendations for many management factors. The various types of birds are:

Commercial, egg-type, Leghorn pullets
Commercial, egg-type, medium-size pullets (most producing brown eggs)
Breeder type:

Leghorn	(male and female)
Medium-size	(male and female)
Meat-type	(male and female)

Isolation of the Brooder House

Chicks should be brooded in a house that is not located near other poultry. There is just too much danger of disease transmission to do otherwise. At least 300 ft (91.1 m) should be allowed between such houses, and a greater distance is preferable. The brooder house should be *isolated*. It should be enclosed with a fence at least 100 ft (30.5 m) from the house, and the gate to the enclosure should be kept locked except when in use.

With modern disease-control programs it will be necessary for everyone entering the enclosure to shower and change into clean clothing. See Chapter 41, Myco-

plasma Visitors must be kept out of the enclosure unless they, too, shower and change clothing

All in, All-out System

Although more than one brooder house may be within the fenced enclosure, the chicks must be of a similar age, the oldest being no more than seven days older than the youngest Vaccination and other programs are almost impossible when chicks are not of a similar age

All the chicks should be started the same week, later all should be removed from the house at approximately the same time This program gives rise to the term, "all in, all-out," meaning that all chicks are placed in the house (or houses) at one time, and some time later, all are moved out at one time *Another group of chicks is not to be placed in the house (or houses) until all the older birds are moved out and the premises cleaned* This provides a period when there are no chicks within the enclosure, thus breaking any cycle of disease infection

PREPARING FOR NEW CHICKS

Everything within the fenced enclosure must be cleaned thoroughly before placing a new group of chicks in the brooder house or houses

Cleaning the House and Equipment

Immediately after the fenced brooding enclosure is depopulated of birds, the house or houses should be cleaned, disinfected, and readied for another group of chicks Immediate preparation is necessary so that the buildings may lie empty for one or two weeks prior to placing new chicks in them Disinfection and fumigation will kill most of any disease producing organisms, an empty house will break the life cycle of most of those remaining The cleaning process must involve the following

(1) *Remove all old litter* Used litter should be removed from the poultry house, then hauled away from the premises
(2) *Clean and scrub the house* All loose debris must be taken from the building, and the floors scraped clean Any slats or wire should be similarly scraped Next, a pressure sprayer should be used to wash thoroughly the interior of the house Following this, it will be necessary to disinfect the entire inside of the building Use the most powerful concentration of disinfectant, as recommended on the label Allow the house to dry If an egg room is in the poultry house, clean it similarly
(3) *Clean the equipment* All equipment must be scraped, washed, and disinfected Dip the smaller items in a disinfecting solution If possible, the equipment should be moved outside the house to an area inside the fenced enclosure to complete the cleaning process After cleaning, the equipment should be moved back into the house
(4) *Fumigation* If the house is tight, or curtains can be closed to keep the fumigant in, the house and equipment should be fumigated, using 3X concentration of formaldehyde gas (See Chapter 9), based on the following

(Per 100 cu ft (2 83 cu m) air space)

Formalin	120 cc
Potassium permanganate	60 gm
or	
Paraformaldehyde powder	30 gm

(5) *Treat dirt floors* Spray dirt floors (also driveways and an area 4 ft (1 2 m) wide around house) with an oil-and-disinfectant mixture, or some commercial product suitable for this purpose

Use a Scrub Bucket

All footwear must be scrubbed with a solution containing a disinfectant before the wearer enters the premises "Step in" pans are of little value, scrub with a good, hard-bristled brush on entering and again on leaving Provide a wide, deep bucket to hold the solution Renew the mixture often

(1) *Let house lie empty* After fumigation, allow the empty house to air out for one or two weeks prior to placing a new group of chicks in it
(2) *Clean any bulk feed bins* All remaining feed should be removed from the bulk feed bins, after which they should be washed, disinfected, and fumigated
(3) *Cleaning other items* Where chicks are brooded and grown in the same house, growing feeders and waterers will need to be cleaned the same time as the brooding equipment With the brood-grow-lay system of housing, equipment used during the laying period will need thorough cleaning too

Caution If any equipment is brought into the fenced enclosure or house, it must be thoroughly cleaned and disinfected first Dirty equipment is one method of transferring disease producing organisms to a clean environment

Check Equipment

While the house is empty of chicks, all poultry equipment should be carefully repaired Any worn or torn curtains on the house should be replaced Winches, cables, and other devices used in conjunction with the curtains must undergo an overhauling Mechanized equipment will need a close scrutiny. Worn out light bulbs should be replaced Ventilating fan motors and other motors may need to be replaced or repaired Gas burners in the brooder stoves should undergo a thorough renovation, remove the carbon, clean the jets, and check the thermostats

Cleaning the Grounds

Remove all debris from the area outside the houses, mow the grass, and make any necessary road repairs Driveways should be properly surfaced to enable trucks to move over them easily during periods of inclement weather If a truck *dip vat* is involved, it should be thoroughly cleaned and fresh disinfectant added

HOW MANY CHICKS

There are several computations necessary to determine the number of chicks to order for any individual house Care should be exercised to work out every detail

according to the type of management program, breed and sex of bird, etc These variations are as follows

Management Program

Will the house be used only for brooding, or will the chicks be brooded and grown in the same house, or will the brood grow lay program be followed? The answer will certainly influence the number of chicks that may be started on a floor of a given area The minimum requirement for floor space for the *oldest* birds kept in the house will determine the number of chicks started, for older birds require more floor space than younger birds

Commercial Pullets or Breeder Birds

As a general rule, all ages of birds to be used for breeding purposes should be given more floor space than those used for the production of commercial eggs Furthermore, males are involved with flocks to be used for breeding purposes, and these need even more floor space In most instances the cockerels are raised in pens separate from the females, at times both sexes are kept in the same pen Thus, the amount of floor space necessary will vary according to the use to which the birds are to be put

Will the Layers Be Kept on the Floor or in Cages?

Although practically all chicks are brooded under similar conditions during the first 5 or 6 weeks of their lives, the handling of the birds after this period, particularly during the laying period, will determine the number of chicks to be started and housed Although the more common practice today is to brood and grow commercial laying birds in the same house, the age at which they are moved to their permanent laying quarters will vary If they are to be kept on the floor during their laying period, they probably will stay in the growing house until about 20 weeks of age If they are to be transferred to cages they may be moved at any time between 14 and 20 weeks of age However, the tendency today is to transfer them at an early age, usually prior to 17 weeks of age As less floor space is required for 17 week-old birds than for older ones, this fact alters the bird capacity of the growing house

In the case of birds that are being raised for future breeding purposes and the production of hatching eggs, there are two alternatives as to the age at which the birds may be housed in their laying quarters

(1) *Transfer at ten weeks of age* More and more breeder birds are being kept under a MG or MS-clean status Breeders are carefully blood tested at regular intervals to determine their freedom from the disease, but the most likely time for flocks to become infected or *break* is when the birds are coming into egg production For this reason it is much better to "house" the birds far in advance of this age, to avoid as much stress as possible at laying age Usually the birds are moved at 10 weeks of age

(2) *Brood grow lay system* This management method has become popular with those poultrymen involved with a Mycoplasma program, because the birds are never moved from house to house, thus avoiding any moving stress and because the poultry house may be completely isolated during the entire life of the birds

Either of these two alternatives will influence the number of breeder-type chicks that may be placed in the house at one day of age, and also the requirements for feeder and waterer space

Chicks Should Be the Same Age

Never mix chicks of different ages in the same house or the same pen. The primary reason for this recommendation is based on the vaccination schedule. When growing birds are vaccinated, all birds in the house should be vaccinated when they are a certain day of age, and on the same day This is impossible if chicks vary in their ages

Floor Space Requirements During Brooding

The amount of floor space necessary for each chick during the first 5 or 6 weeks of its life is given in Table 13 1 The figure varies according to the type of bird involved, and the purpose to which it is to be put in the laying or breeding pen

TABLE 13 1

FLOOR SPACE REQUIREMENT DURING THE BROODING PERIOD

Type of bird	Floor Space per Bird Sq Ft	Sq M	Birds per Sq M
Leghorn, egg type pullets	0 75	0 070	14 3
Medium size, egg type pullets	0 85	0 079	12 7
Leghorn breeder pullets	0 85	0 079	12 7
Leghorn breeder cockerels	1 00	0 093	10 8
Medium-size breeder pullets	1 00	0 093	10 8
Medium size breeder cockerels	1 25	0 116	8 6
Meat type breeder pullets	1 00	0 093	10 8
Meat type breeder cockerels	1 50	0 139	7 2

Floor-space requirements for birds of other ages are found in Chapters 14, 15, and 16

Pens and Floor Space

Except for birds to be used as breeders, pens probably are not advisable Although pens were widely used several years ago, the procedure today is to house most birds in large groups, several thousand may be kept together Breeder-type birds, however, seem to do better when the unit size is small, and 400 to 500 usually are placed in one pen It is best to keep the breeder males and females in separate pens during the brooding period. The use of pens within a house does not alter the floor space requirement shown in Table 13 1.

Effects of Crowding

Chicks should be given adequate floor space during the brooding period, they should not be crowded The amount of floor space given in Table 13 1 does not involve crowding. Although the amounts vary according to the type of bird being brooded, some birds or sexes require more room in which to move about. Certain chicks, as meat-type cockerels, are costly and small compared with other birds

They necessarily must have more floor space than other types of chicks to avoid any crowding

A decrease from the recommended floor space usually means an increase in chick mortality and reduced rate of growth Although the latter is not of primary importance with birds to be kept for egg production purposes, any increase over a "normal" death loss becomes costly Not only is there a monetary loss involving the cost of the chick, but the value of the feed, labor, and other items necessary to grow the chick until the time of death is a direct loss too

How much mortality during brooding? Normally, chick mortality during the first week in the brooder house is greater than any week thereafter during the growing period, but it should not be over 1% Losses the second week should be slightly less Beginning with the third week, deaths should be at a relatively low weekly level and run rather constant until the end of the growing period

Order Chicks Well in Advance

Chicks should be ordered weeks, or even months, in advance of the time they are to be placed in the brooder house This gives ample time for the hatchery to plan for the order, and for the customer to have some assurance that he will get the chicks when he wants them

First, calculate the number of chicks needed Usually, the quantity of day old, female chicks needed is determined by the number of pullets necessary at sexual maturity To this figure is to be added the number of cull and death losses during the growing period Also to be considered is the number of *extra* chicks given by the hatchery

Example

Number of pullets at sexual maturity	4000
Number of chicks started if 90% are to be housed at sexual maturity (4000 − 90 X 100)	4444
Culls and death loss (4444 - 4000)	444
Number of chicks needed when 4% extras are given (4444 − 104 X 100)	4273
Number of chicks to order (to nearest 100)	4300

Growing mortality a factor In the above example, 90% of the birds started are to be *housed* at sexual maturity Certainly, the goal of every poultryman should be at least this, but many will have a much higher figure, particularly with egg type lines However, others will *not* do as well

Extra Chicks Hatcheries have a custom of giving free *extra chicks* to make up for those lost in delivering the order plus a normal amount of early death loss Between 2 and 4% extra chicks usually are included

When cockerel chicks are needed If the flock is to be used for breeding purposes once they reach maturity, it will be necessary to calculate the number of cockerels necessary according to the number of pullets, then order the required number of male chicks

Ordering chicks for the brood grow-lay house The number of pullets needed in the house when they reach laying age in the figure used to determine the number of chicks to start at one day of age Using figures

for floor space (Chapters 15 and 16), calculate the number of mature pullets the house will accommodate. From this figure, work backward to calculate the number of day-old chicks necessary. Brooding and growing mortality, plus culls, must be included in the computation. The amount of floor space for the young chicks during the brooding period will be much less than the total floor space in the house. Therefore, it may be practical to confine the brooding operation to only a part of the building.

BROODING REQUIREMENTS

A few days before the chicks are due to arrive at the farm the caretaker must begin to ready the poultry brooder house. Everything must be in order. A good start is an important part of the growing program.

Litter

There are many types of litter, and an evaluation of these is found in Chapter 20. Cover the floor with about 2 in. (5.1 cm) of the material. The particles should be large enough not to pass a 1/4-in. (0.6-cm) sieve. Be sure it is clean, dry, and free of any mold. Do not cover the litter with paper or cloth unless the litter is extremely fine, i.e., will pass a 1/4-in. (0.6-cm) sieve.

Delivery warning: Remember that the fenced enclosure and the brooder house have been thoroughly cleaned and disinfected. Any truck used to transport litter to the house should also be clean before it enters the enclosure. Do not undo a good job of cleaning the house by admitting dirty trucks to the premises. Install a "dip vat" at the entrance. Trucks must drive through a disinfecting solution kept in the dip vat.

Litter Management.—During the first three weeks of the chick's life the litter should be only slightly moist; after that it should contain about 25% moisture. Do not start the brooder stoves until the day before the chicks arrive, as this tends to dry the litter too much. When chicks are placed on exceptionally dry litter there is a tendency to dehydrate them the first day. After that, the droppings add moisture to the litter. If the litter becomes too wet, increase the amount of air moving through the house.

When all else fails: If increased ventilation will not dry the litter, more litter should be added to the house, mixing the new with the old. But be careful. Often molds grow under wet litter; stirring or turning the litter only exposes more moldy material to the chicks. Remove caked or wet litter before adding more.

Feathering and litter condition: There must be some humidity in the poultry house. Chicks do not feather well in a dry atmosphere, and the moisture in the litter tends to influence the amount of dampness in the air. The area near the heat supply has a tendency to get wet because the birds frequent the area more, and because the warmed area is small; but other parts of the house may be too dry. Both may become problem areas.

Brooder Guards

Brooder guards should enclose the heated area, either the brooder stoves, the hot-water pipes, or the heated slab. The type of canopy brooder will determine

the distance the guards should be from the edge of the hover type stove The guards will need to be farther from the blast type stove than the conventional, but normally the distance should be about 30 in (76 2 cm) in winter and 36 in (91 4 cm) in summer

Increase the area within the guards As soon as the chicks learn the source of the supplementary heat, the guards must be expanded to allow a greater area inside them Begin increasing the area on the third day Guards should be used for 6 to 9 days, after which they may be removed Often the guards may encircle two or more brooder stoves after the fourth or fifth day and larger waterers and feeders placed inside the rings Many pullet chicks are debeaked and some males are toe-clipped at 6 to 9 days of age, if this is practiced the chicks should remain in the guards until these jobs are completed

Guards with room type heating Although chicks cannot move away from warmth when the entire brooder house is heated, they may not be able to find the feed and water if they are allowed to stray over the entire floor area It is just impossible to provide enough feeders and waterers There fore, guards will be necessary to restrict the chicks to a small area where the feed and water is more easily available

Attraction Lights

An attraction light should be used under hovers which confine their heat to a small area The presence of brooder guards does not remove the need for lights The light should be used for two or three days only, chicks will learn the source of heat during this time

House Ventilation For Hover type Brooding

There need be but little air movement through the brooder house during the first few days, 3 to 5 air changes per hour will be ample The house temperature should be kept at about 75°F (23 9°C) the first 4 or 5 days, after which it should be lowered to 65° to 70°F (18 3°–21 1°C) Chicks do better in a relatively cool environment if there is a place they can go to get warm

Ventilating the open sided house Curtains should have been installed on this type of house When chicks are placed in the house, the curtains should be closed As the chicks grow older the curtains may be opened more during the warm hours of the day, and closed at night Weather conditions and the age of the chicks will determine the day time and night time opening size There must be no drafts in the house

Avoid disaster Ventilation in the open sided house is difficult to control But regulating the amount of air going through the poultry house is *most important* Changing the curtains according to the outside and in side temperature is a prime factor in raising good birds Its importance cannot be overestimated Alterations may be necessary several times a day Just opening the curtains in the morning and closing them at night is not enough Improper ventilation and house temperature will only lead to difficulties in the flock sometimes to disaster

Plastic curtains inside the house When the outside temperature gets very low it may be impossible to keep the temperature of the brooder house

high enough for chick comfort. Even the surplus heat from the brooder stoves will not warm the house enough. A *remedy* for this that is used in some instances is to hang two clear, plastic curtains from near the ceiling to near the floor, extending them the length of the house. One is hung on each side of the area in which the stoves are located. In this manner only about half of the floor area is used until the chicks get older and can withstand cooler conditions. *Be careful*, however, that ventilation inside the curtains is adequate. Leave some air space at the top and bottom of the curtains. Remove the curtains when the chicks are 2 to 3 weeks of age.

Ventilating the environmentally controlled house: After the chicks are a few days old, air movement through the brooder house will need to be increased to furnish a proper environment. The size and number of birds in the building are the factors used in determining proper airflow. See Chapter 11.

Light

Artificial light must be used to supplement natural daylight during the first 48 hours after the chicks arrive at the farm. Chicks should be given continuous light at 1 foot-candle illumination at the floor during this period. This amount may be supplied by approximately 1 watt of light bulb for each 4 sq ft (0.37 sq m) of floor space. In the open-sided house this means that artificial light must be used during the hours of darkness, but if the inside of the house is dark during daylight hours, artificial light should be used both day and night. In the totally dark, environmentally controlled house, artificial light, of course, should be used for the first 48 hours.

Continuous light during the first two days is a great aid in getting the chicks to eat and drink; and this is of the utmost importance. *The first two days is a critical period.*

Brooder Capacity

The brooder capacity is related to the area of the floor that is heated by the heat unit. The size of the canopy has little to do with it, as some heating devices deflect the heat farther than others. Besides, the type of chicks being brooded will alter the number of chicks that can be placed around one unit.

Commercial and breeder-type pullets: Most canopy-type brooders have a capacity of 500 chicks, and this is the number usually placed under a stove by commercial growers.

Meat-type breeder cockerels: When the cockerels are to be raised separate from the pullets, a smaller number should be placed under each brooder. About 350 chicks per stove is the usual recommendation.

Brooders heated with hot water: Allow approximately 6 sq in. (38.7 sq cm) per pullet chick and 8 sq in. (51.6 sq cm) per cockerel chick under the hot-water hovers. The recommendation will vary according to the height of the pipes above the litter. The shorter the distance, the more space required per chick, because the nearness of heat tends to drive the chicks out from under the hover and they will not use the entire area under the hot pipes.

Slab heating When a warmed slab of concrete floor is used as the source of supplementary heat, provide about 20 to 25 sq in (129–161 3 sq cm) of heated slab per chick to be brooded

Brooding Temperature

It is difficult to recommend any brooding temperature applicable to all types of brooders and all conditions Usually, however, a temperature of 90° to 95°F (32 2°–35°C) at a point 6 in (15 2 cm) outside the canopy and 2 in (5 1 cm) above the top of the litter is satisfactory for chicks at one day of age Use the higher temperature for meat type, breeder, cockerel chicks As all chicks grow older, the temperature may be reduced at the rate of about 5°F (2 8°C) per week But a thermometer is a poor tool for measuring *chick comfort* The chicks themselves should be the indicator At night they should bed down just outside the edge of the hover, and completely circle the brooder If they are too far out, the temperature is too high, if too far in, the temperature is too low Thermometers should be used before the chicks are placed under the hovers, but after the first two days, thermometers may be removed and stored

The usual starting recommendation for room heat brooding, and for slab brooding is 85°F (29 4°C) at a point 2 in (5 1 cm) above the top of the litter

Make sure of this Extreme care should be taken to reduce the brooding temperature with room type heating With heat in the entire house, the chicks have no way of getting away from it if they are too warm Furthermore, they have no place to go if they are cool and require additional supplemental heat If the temperature is correct, the birds will spread out evenly over the floor or in small congregations at night, they will not huddle nor extend their wings

A similar precaution is necessary with slab heating Although the chicks can move off the heated slab if they are too warm, there is no place for them to get additional heat if they are too cool

Another suggestion Although *brooder guards* are necessary to confine day old chicks to the heated area, and to concentrate the feeders and waterers within a small area, often the guards are responsible for chick injury Although solid guards prevent a great deal of draft over the chicks during cool weather, the birds may develop a custom of congregating against them the first day to keep warm, rather than going to the heated area of the brooder stove During hot weather there is a tendency for the stove to become too hot, forcing the chicks away from the heat and against the guards, where they pile in their endeavor to get away from the heat For this latter reason mesh wire, rather than solid material, is recommended during hot weather *Be careful to adjust the brooder heat so the chicks stay away from the guard*

Watch the chicks During the first two weeks of life, chicks are easily stressed Sudden changes in temperature, light, ventilation, water and feed supply, and noise will produce observable deterioration in the quality of the birds Frequent visits to the brooder house are necessary during this period Watch every detail, do not make a casual observation Check the house at night and see that everything is normal

Increase brooder heat if needed: Be ready to increase the brooder heat if chicks appear chilled during a stress created by vaccination, debeaking, etc. Keep the birds comfortable at all times.

WATER AND FEED

Chicks must learn quickly to eat and drink. Although they can get along without feed or water for up to three days after hatching, such a delay will be injurious. Chicks should be fed and watered within 24 hours after hatching; sooner is even better. Any delay only dehydrates and weakens the chicks; and weak chicks do not learn to eat as rapidly. Experimental work has shown that chicks should drink before they eat, but the common field procedure is to have both water and feed available when the chicks arrive at the farm.

Water

Water is important for it serves many functions in the chicken, some of which are:

(1) It helps to cool the bird by evaporation through the lungs and air sacs.
(2) It makes up a high percentage of the body.
(3) A high percentage of the egg contents is water.
(4) It aids in softening the feed in the crop, and forms a carrier during its passage through the alimentary tract.
(5) It aids in certain digestive processes.
(6) Water is an important part of the blood and lymph.

Number of waterers: Provide 2 fount-type chick waterers for every 100 pullet chicks the first 2 weeks. With 500 chicks to a stove, this will mean 10 waterers per brooder. The waterers should be placed just *outside* the edge of the hover and on the litter so that the water level will be convenient to the chicks. After 2 days the founts should be placed on stands about 1 in. (2.5 cm) high to keep litter from getting in them. Availability of drinking surface is the criterion with day-old chicks rather than the amount of water in the founts; several small waterers are better than a few large ones.

Water temperature: Fill the founts about 4 hours before the chicks arrive. This allows time for the brooder heat to warm the water. The water temperature should be 65°F (18.3°C), and over. *Do not use old, stale water.* It must be fresh.

Sanitizers in the drinking water: Many commercial poultrymen use a sanitizer in the drinking water for varying periods of time. The procedure may, or may not, have merit in reducing losses from disease. But such a practice is detrimental if water-type vaccines are to be used, as water sanitizers reduce the efficacy of the vaccine, sometimes causing the vaccine to become completely ineffective.

Remember: Although water sanitizers may be used in the water the first few days, they must not be used when the larger waterers are put in operation if water-type vaccines are to be employed. Most larger waterers are of the automatic type, and extreme care should be exercised. *Don't forget* that all water lines and waterers must be flushed and cleaned

prior to water vaccination if sanitizers have been used in the water system.

Neutralizing drinking water sanitizers. If it is impossible to flush the sanitizer from the water system prior to vaccination, dried skim milk may be added to the drinking water to neutralize the sanitizer. See Chapter 43.

Clean and disinfect the waterers. Chick founts and other waterers should be cleaned each day using a scrub brush, then emptying the old water from the fount. A disinfectant must be added to the scrub water to facilitate destruction of microorganisms and to aid in preventing mold growth.

Caution. When vaccines are being added to the drinking water do not use a disinfectant in the scrub water used to clean the waterers. Some of it will remain in the waterer and lower the effectiveness of the vaccines.

Be sure the chicks are drinking. Just to provide an adequate number of waterers is not enough, chicks must drink soon after being placed under the brooder. Any delay only produces dehydration, and makes it difficult for birds to get off to a good start. Be sure *all* the chicks are drinking. Too often it appears that they are drinking, but close observation will reveal that some of the birds are not getting to the founts. If this is a gen

TABLE 13.2

WATER CONSUMPTION OF 100 PULLETS PER DAY

	70°F (21.1°C) and below				90°F (32.2°C)			
	Leghorns		Meat type		Leghorns		Meat type	
Week	Gallons	Liters	Gallons	Liters	Gallons	Liters	Gallons	Liters
1	0.60	2.27	0.95	3.60	1.03	3.90	1.64	6.21
2	1.05	3.97	1.68	6.36	1.80	6.81	2.90	10.98
3	1.38	5.22	2.20	8.33	2.38	9.01	3.80	14.38
4	1.62	6.13	2.60	9.84	2.80	10.60	4.48	16.96
5	1.86	7.04	2.97	11.24	3.20	12.11	5.12	19.38
6	2.04	7.72	3.25	12.30	3.52	13.32	5.60	21.20
7	2.25	8.52	3.40	12.87	3.88	14.69	5.87	22.22
8	2.43	9.20	3.52	13.32	4.20	15.90	6.07	22.98
9	2.70	10.22	3.68	13.93	4.65	17.60	6.35	24.04
10	2.82	10.67	3.85	14.57	4.92	18.62	6.65	25.17
11	3.00	11.36	4.05	15.32	5.18	19.61	7.00	26.50
12	3.15	11.92	4.20	15.90	5.43	20.55	7.25	27.44
13	3.30	12.49	4.35	16.47	5.70	21.84	7.50	28.39
14	3.45	13.06	4.50	17.03	5.95	22.52	7.77	29.41
15	3.60	13.63	4.65	17.60	6.20	23.47	8.02	30.36
16	3.75	14.19	4.80	18.17	6.47	24.49	8.28	31.34
17	3.87	14.65	4.95	18.73	6.68	25.28	8.55	32.36
18	4.02	15.22	5.10	19.30	6.93	26.23	8.80	33.31
19	4.14	15.67	5.25	19.87	7.14	27.02	9.05	34.25
20	4.26	16.12	5.40	20.44	7.35	27.81	9.32	35.28
21	4.41	16.69	5.55	21.01	7.61	28.80	9.57	36.22
22	4.50	17.03	5.70	21.58	7.76	29.37	9.83	37.21

The above table was calculated from feed consumption figures normal for medium-sized strains of birds. Leghorns had full feed; meat-type pullets had a restricted feed intake comparable with present-day field recommendations.

eral problem on the farm, increase the number of waterers, and increase the amount of artificial light the first two or three days

Water consumption The consumption of water is highly variable, being influenced by the age and size of the birds, the ambient temperature, and the texture and makeup of the feed Approximations are to be found in Table 13 2, but see Chapter 11 for more details

Note It must be remembered that as temperature increases, feed consumption decreases Therefore, relative water consumption at 70°F (21 1°C) and 90°F (32 2°C) also is associated with feed consumption

Metering water consumption Small meters are available for determining the water consumption of a flock of chickens These are to be placed in the incoming water line Water consumption is important and these meters offer an excellent means of evaluating the daily water intake of a flock A sudden drop in water consumption if often the first indication of trouble in the flock

Feed

Although the subjects of nutrition and feeding are covered in detail in Chapters 25 through 37, there are certain items that are best discussed in this section

Most poultrymen have little to do with the formulation of the feed they give to their chickens, but they do have a direct responsibility to see that the feed is supplied clean and in amounts adequate to furnish the nutritional needs of the bird This in itself is a very scientific subject, and involves many factors

Feed delivery Fresh feed is advisable It should be delivered to the poultry house about once a week Bulk feed tanks should be of a size that will handle 7 days of feeding with about 2 days of reserve supply

Clean feed trucks Many programs of poultry production are built around complete cleanliness and isolation of the birds Anyone entering the premises must first shower and change to clean clothing But how to properly disinfect a feed truck at the time feed is delivered is one of the most baffling of management problems, as well as one of the most important To disinfect the tires, the truck may be driven through a dip vat containing water to which a good disinfectant has been added The cab and under parts of the chassis may be sprayed with a similar solution Some have built "tents" into which the loaded truck may be driven, then fumigated with formaldehyde gas Although it is probably impossible to completely disinfect the trucks that deliver the feed, extreme precautions should be taken to do the best job possible, for feed trucks represent an important avenue for the entrance of disease producing organisms into the poultry house

The first feed For the six-week brooding period, chicks need to have feed available at all times During the first few days of their life it is important that the feed be *easily* available For this reason, large, flat containers make the most suitable feeders Inverted chick box lids or similar trays should be used Supply one such feeder for every 100 chicks Some use egg flats Provide two of these for each 100 chicks Give the first feed by sprinkling it over the entire area of the feeder lid or container just prior to

the time the chicks arrive Feed should be fresh, feed little and often the first few days

All chicks must eat Be sure that each chick is eating at the start Provide plenty of light on the feed to make it easier for the young birds to see to eat Keep the brooder heat high enough so the chicks do not have to stay under the hovers—away from the feed—to keep warm Place the feeder lids outside of the area covered by the brooder canopy so as to provide better light This procedure also prevents feed from drying as much as when the feed is placed under the hovers and closer to the heat supply

Watch for 'starve-outs' Some chicks will have difficulty in learning to eat, resulting in what is known as "starve-outs" Examine some of the seemingly timid chicks the first day to see if their crops are full After a few hours on feed the first day a chick should have a well filled, distended crop If not all the chicks are eating, see where the trouble lies, and correct it

How to help prevent vent pasting On certain farms and during some seasons of the year chicks will develop a laxative condition leading to vent pasting during the first few days after they begin eating Often this may be avoided if the chicks are given some cracked corn (or cracked wheat or cracked milo) as a part of their first feed Preferably, the corn should be cracked with a roller, then screened to keep only the smaller particles while eliminating the powdery material It should be sprinkled on top of the regular first feed Do not feed all corn, and feed the cracked corn for only two days Feed about 10 lb (4 5 kg) for each 1,000 chicks during the two-day period

WHEN THE CHICKS ARRIVE

Preparedness is of great importance in getting ready for the chicks, but once they arrive at the farm many management factors are involved This list is long but necessary, a complete understanding of each item is the manager's responsibility

Lock the House

During the cleanup period and thereafter, the fenced enclosure and the house must be kept locked No visitors should be allowed unless they shower and use clean clothing Poultry house doors should be self locking once the door is closed These have the advantage of keeping other people out once the attendant is inside the building

Chick Delivery

Chick trucks go from farm to farm Normally, they are cleaned and fumigated at the hatchery after every delivery But make sure, ask the driver Furthermore, the cleanliness of the driver should be an issue Is he dressed in clean clothing? If there is any doubt, he should not be allowed in the fenced enclosure, chicks should be taken to the house by farm personnel who have showered and put on clean clothing

Destroy the chick boxes Unless the chick boxes are made of plastic, or

some similar material, and are reusable, they should be destroyed on the farm. Nowadays, with so much dependent on disease-control programs, it is poor practice to return fiberboard boxes to the hatchery.

Chick Arrival Time

Chicks should arrive at the farm early in the morning so they will have the entire day to learn to drink and eat and be under close observation. Request this of the hatcheryman. During hot weather it is important that the chicks be transported during the cooler hours of the night, arriving at the farm soon after sunrise.

Examine the chicks: Make an examination of several boxes of birds, checking on mortality, quality, and thriftiness. Ask the driver for a delivery form and make any notations as to number and condition of the chicks at the designated space on the form. Both the driver and the customer should sign.

Dump the chicks quickly: Remove the lid and tip the boxes over quickly, "dumping" the chicks near the brooder heat.

Day-old vaccination: Some day-old vaccination may be needed. Sometimes this is done in the hatchery; at others it is done in the brooding house. This will necessitate a slow process of removing chicks from the boxes, vaccinating them, and transferring them to the brooder area—another reason for an early arrival of the chicks. If vaccinating crews come on the farm to do the work, be certain that they shower and dress in clean clothing before entering the premises.

Caution: Dispose of all empty vaccine vials after vaccinating is completed. Put them in a solution containing a disinfectant or burn them.

LARGER EQUIPMENT

Chick founts and flat-type feeders are essential for starting chicks, but their usefulness is short-lived; soon larger equipment must be substituted.

Make changes gradually: Chickens are creatures of habit; they dislike having their daily routine changed. Any variation in a management procedure must be made over a period of time. When changing equipment within the poultry house leave the old equipment at its usual location for several days after the new is added, or slowly move the old equipment to the location of the new.

Larger Waterers

When the chicks are between three and five days of age, larger waterers should be placed within the brooder guards. These vary in type and construction (See Chapter 12), but the recommendations for waterer space are basically the same. Leave the small chick founts inside the guards until the birds are about seven days of age; then begin taking a few out each day so that they all are removed when the chicks are about ten days of age.

Waterer space: The larger waterers used until the chicks are 6 weeks of age should provide approximately 0.6 in. (1.5 cm) of drinking space per chick when the water is supplied in troughs or pans. If drinking cups are used, supply three for each 100 chicks.

Height of waterers: The second waterers should be raised gradually as the

chicks grow older Adjust them so that the water level is 1 in (2 54 cm) above the backs of the birds

Larger Feeders

Flat-type feeder lids will suffice but a few days When the chicks are three days of age add larger feeders, then gradually remove the feeder lids, taking a week to complete the job In most cases automatic feeders may be used after the third day by placing the brooder guards just outside them, but if this is not possible it will be necessary to use small trough type feeders until the birds have access to the automatics If hanging feeders are to be used during the growing period, they should first be set on the floor inside the brooder guards The chicks will get into them, but this is not to be discouraged until the birds are older At the start, feeders should be kept full, later, the feed depth should be reduced Keep the chain covered in automatic troughs with chain drags In pan type automatic feeders, keep a minimum of feed in the pans Regular trough type feeders should be about one third full Reducing the feed level after the chicks can reach the bottom of the trough or pan will decrease feed wastage, and keep the feed cleaner

Feeder space requirement When feed is furnished in troughs, provide 2 in (5 1 cm) of feeding space per growing chick through the sixth week If pans are used, provide the following number

12 in diameter pan	3 for each 100 birds
16-in diameter pan	2½ for each 100 birds

Height of the feeder After the chicks can reach the feed without getting into the feeder, adjust the height so that the bottom of the trough or pan is 1 in (2 54 cm) above the backs of the birds

Location of the feeders The birds should have easy access to the feed Feeders should be distributed uniformly throughout the house No bird should have to go over 10 ft (3 05 m) to get either feed or water

When a slat floored house is used In many instances, houses will have a part of the floor covered with slats This raises a problem as to where to place the feeders and waterers for the young birds Older birds usually are fed and watered from automatic equipment placed on top of the slats But inasmuch as young chicks will not use the slats until they are several weeks of age, it will be necessary to provide second feeders and waterers that can be placed on the littered floor

Check for feed wastage Regularly examine the litter around the feeder to see if feed is being "beaked" from the feeder, and wasted A small percentage lost increases the feed cost by a similar percentage If feed is being wasted, lower the level of feed in the troughs or pans, and check the grill or reel space

Grills and reels on feeders Many feed troughs have either a wire grill or a reel over them to prevent birds from getting into the feeder Although most of these serve their purpose, care should be taken that they do not restrict the feed intake Grills or reels with too small an opening will delay the time necessary for a bird to eat, thereby increasing the requirement for feeder space

JOBS DURING THE BROODING PERIOD

During the first six weeks of the chick's life several management programs must be initiated. Many create a stress, and extreme care should be taken to minimize the effects on the bird.

Debeaking

Cannibalism is prevalent among chickens of all ages and some method of preventing this vice must be used. The common procedure is to debeak the birds, but the age at which they can best be debeaked is debatable, even though the operation may be completed at any time prior to the onset of egg production. The criteria for a good job are twofold:

(1) Create as little stress as possible.

(2) Cut the beak so that it will not grow back to normal length.

Debeaking is a precision operation, and experience is a great asset in doing it properly. Making the cut at the right place is of prime importance. Too often debeaking is done carelessly, creating more stress than necessary when the beak is cut too short, or by not removing enough, which allows the beak to grow and eventually regain a near-normal length.

Young chicks may be debeaked at 2 ages; 1 day of age and at between 6 and 9 days of age.

Day-old debeaking: Many chicks are debeaked at this age, but the results are variable, as it is more difficult to debeak day-old chicks uniformly; the beak is too small. Furthermore, the stress from the removal of the beak comes at an age when chicks are learning to eat, a serious detriment to normal feed consumption.

There are two methods of day-old debeaking:

(1) *Cold debeaking:* On the market are automatic debeaking instruments for cutting the beak with a cold knife. Although cold debeaking has some merit for broiler chicks, there is no heat to deaden the beak tissue, and the beak eventually grows back. Thus the birds must be debeaked again before they reach the laying pen.

(2) *Hot debeaking:* A debeaker that has a hot cauterizing blade is used to remove a portion of the upper beak, or a portion of both the upper and lower beaks.

Six-to-nine-day debeaking: This is hot-type debeaking, and is one of the ages recommended for debeaking pullets to be used for commercial layers or for breeding purposes. However, because of lack of experience, many have had failures when debeaking at this age. The method calls for extreme precision; it is often called *precision debeaking.* When done properly, the results probably will surpass all other methods. Chicks are easy to handle at this age, and when the beak tissue is cauterized correctly, the beaks will not grow back; there is no need for a later debeaking.

How to do it: The pullet chicks are to be debeaked with an electric debeaker having a plate with a 11/64-in. (0.44-cm) hole. The beak is inserted in the hole and a hot blade (1500°F) drops down to make the cut. The hot blade also acts as a cauterizer, and the severed beak must be kept in contact with the blade for three seconds—no more, no less.

The time is important, keeping contact too long will produce additional stress, too short a time will not prevent the beak from growing back Both the upper and lower beaks are to be removed, but the chick's head should be tilted downward so as to cut the upper beak slightly shorter than the lower This is known as *block debeaking* Hold the head with the thumb on the back or side of the head, placing the forefinger under the throat This causes the chick to pull its tongue back and out of the way of the hot knife Remove approximately half of the upper and lower beaks, or at a point about two thirds the distance from the tip to the nostrils With experience, one can debeak up to 1,000 chicks per hour by this method But *do not hurry*, the prime requisite is not speed, but precision

Debeaked bird at maturity If debeaking is done properly at 6 to 9 days, practically all growth of the beak is arrested At the bird's maturity the upper and lower beaks will be well rounded, with the upper beak slightly shorter than the lower

Debeaking cockerels Six to nine-day old cockerels, to be used later as breeders, should be debeaked at this age in a fashion similar to that in which pullets are debeaked

Caution Although cockerels may be debeaked at 6 to 9 days of age, *do not debeak older cockerels as severely* See Chapter 14

Avoid trouble Newly debeaked chicks will have trouble tripping the valve in trigger type, cup waterers If these are to be used as second waterers, *be sure* the chick founts remain in the pen for several days after debeaking is completed

Notch type debeaking A special "V"-shaped cauterizing blade may be used to debeak chicks at 6 to 9 days of age The bird is held on its side and the angled blade cuts a notch in the beak so that the inner portion is deeper than the upper and lower The theory behind this method is that the inability of the bird to close the end of its beak tightly makes it more difficult for it to pull feathers or become cannibalistic Acceptance of this procedure has been slow, mainly because it offers little, if any, advantage over precision, block debeaking, and because this debeaking procedure takes more time

Debeaking older birds There are several ways of debeaking older birds These are discussed in Chapter 14

Results of debeaking There are advantages and disadvantages to debeaking, but certainly the advantages far outweigh the disadvantages Cannibalism in a flock, either through feather pulling, picking, vent nipping, or fighting sometimes can lead to disaster It gets to be habit-forming, a few canni balistic birds instill the character in others, and soon the entire flock is affected

Advantages of early debeaking

(1) Chicks are easier to handle
(2) Toe picking is stopped at an early age
(3) Less interference with later vaccinations
(4) Helps to prevent early feather picking and cannibalism

(5) Feed efficiency is improved
(6) Better livability, fewer culls
(7) Birds have many weeks to recover from the stress
(8) More uniformity of the birds in the flock

Disadvantages of early debeaking Many of the following disadvantages apply to debeaking at any age prior to sexual maturity

(1) Chicks will lose weight for one to two weeks after debeaking
(2) Growth rate is reduced for a long period after debeaking, it will take from 10 to 20 weeks for a bird to attain the weight of a similar nondebeaked bird, full fed
(3) Sexual maturity is delayed if over half of the beak is removed at 6 to 9 days
(4) Early debeaking (or at other ages) may slightly reduce annual egg production, but will have no effect on egg size

Don't debeak when birds are under stress Debeaking at any age is in itself a severe stress Don't debeak when there is a stress from some other cause, wait until the birds recover and return to normal

Toe Clipping Males

The inside and back toes of all breeding males should be clipped A special piece of equipment is best suited for this purpose See Chapter 6 Clip the toes at the outer joint, just behind the toenail Although the clipping is best done in the hatchery, toes may be clipped at the time the 6 to 9-day debeaking is done

Dubbing

Removing the comb, or *dubbing*, is a practice followed by many poultrymen It prevents the comb from being injured during fighting and picking, provides better vision, and reduces the damage done by frost bite It also reduces injuries incurred when the comb comes in contact with feeder and waterer grills and reels, and with wires in cages Normally, all cockerel chicks should be dubbed On a farm where comb damage in pullets has been excessive, they too should have their combs removed

How to do it Dubbing is best done when the chicks are one day of age With a pair of manicuring scissors, cut the comb off close to the head, running the shears from the front to the back of the comb The concave side of the scissors should be up

Vaccinating During the Brooding Period

There are several vaccinations that may be given before the chicks are six weeks of age Programs for vaccinating are discussed in Chapters 41 and 43

Vaccination stress Most vaccinations cause some stress, sometimes the vitality of the flock is lessened severely Feed intake will decrease, and the birds will huddle near the heat It may become necessary to increase the heat supply to keep the birds comfortable Often it is practical to add medicaments to the drinking water to treat a stress condition Sometimes the addition of soluble vitamins to the water will help alleviate any condition brought on by inadequate feed intake Be careful about vaccinating

when stress from another cause is evident, or when the flock is being medicated Adding one stress to another only increases the flock problems

Coccidiosis Control

Most chicks are on some type of coccidiosis-control program during the brooding period As coccidiosis continues to be one of the most important diseases during the growing period, care should be taken to provide a good coccidiostat in a quantity adequate to completely suppress the multiplication of the oocysts See Chapter 41 If the CocciVac program of coccidiosis control is being used, follow the directions carefully Regardless of the program, be on the lookout for any evidence of coccidiosis ruffled feathers, droopiness, bloody droppings, etc Treat quickly

Hot Weather Problems

Although young chicks can tolerate higher temperatures than older birds, environmental heat may create a severe stress Birds eat less and drink more water Be sure there is adequate trough space It may be necessary to increase the amount of watering space if the chicks are crowding the waterers

During hot weather litter problems may be accentuated Most of the added water drunk will be deposited in the litter through fecal elimination Increased air movement through the house will help alleviate the condition, but if this does not improve the litter condition, try the following

Add 5 lb (2 27 kg) of superphosphate to each 100 sq ft (9 29 sq m) of floor space Stir and mix the phosphate with the litter *Do not use lime*

Cold Weather Problems

Cold weather problems should be minimized Better housing has done a great deal to provide a higher temperature within the poultry building During the brooding phase, supplementary heat is added to increase the warmth during the first few weeks, but birds should not need heat after they are four or five weeks of age It is the period when brooder heat is being withdrawn, and after, that leads to trouble in the cold house Respiratory diseases increase, birds eat more feed in their endeavor to warm their bodies, and houses are harder to ventilate Stresses are created to add to those already brought on by debeaking, vaccinating, etc

Growing Management

Following the brooding period comes the growing period. Probably no other age of chickens commands the respect of management more than the period between the time they are six weeks of age and sexual maturity. How well a bird is grown will greatly determine how well it does in the laying or breeding house. One's ability to raise a good pullet or cockerel is a requisite of a profitable poultry flock. Sound management during the growing period is the end point of competent training and the ability to put recognized poultry practices to work. Those who can't raise a high-quality pullet will be plagued with difficulties during the laying period. Pullets maturing with poor quality may not show the effects of mortality during the egg production cycle, but the results will be far from satisfactory. Egg production will be poor, egg quality and size inferior, feed costs excessive, and many other factors will be far from normal. All of these conditions will exert their influence on lowering the profitability of the flock.

Good management during the growing phase will be closely associated with the time the caretaker spends with the flock. In this day of so much automation in the chicken house, too many poultrymen feel there is little need for frequent visits to the flocks. And when they do go into the building, it is only to see if the automatic equipment is operating smoothly. But the man who attends to details and keeps his growing flocks under close observation will achieve the best results. Not only must there be a detailed program for growing birds, but care must be taken to see that the program is carried out. Too often there is no resemblance between the written program and what is actually done in the poultry building.

THE GROWING HOUSE

Formerly, young chickens were moved from the brooding house to the growing house at about six to eight weeks of age, but with many modern disease-control programs this is no longer an accepted practice. Commercial egg-type pullets are kept in the same house from their first day until they are to be moved to their laying quarters, either cages or littered floor houses. More and more growing birds, to be used later for breeding purposes, are involved with a program for the eradication of *Mycoplasma gallisepticum* and *Mycoplasma synoviae*. For this reason the birds are left in the brooding house until they are ten weeks of age, when they are moved to the growing-laying house, or they remain all their lives in one house, where brooding, growing, and egg production are completed. These programs complicate the picture of housing, but it can be stated that there is hardly a place today for the separate growing house as it was known in the past.

Brooding House as Growing House

Although the actual brooding period usually is confined to six weeks, birds today are seldom moved from the brooding house until they are at least ten weeks of age. Thus the brooding house becomes one for brooding and growing. Floor space and equipment requirements have been given in Chapter 13 for chicks up to 6 weeks of age, but when chicks remain in the same house for the first 10 weeks,

care must be taken to provide more floor space, more feeder space, and more waterer space, the latter being especially important during hot weather when there will be a great increase in water consumption

Although most brooding houses have adequate air movement through them to suffice for six weeks, many may be poorly ventilated during the next four weeks After the first six weeks, birds are heavier, grow faster, and occupy more house space, all require an increase in airflow to remove moisture from the building Be sure that the necessary increase is provided

Breeders involved most Keeping the chicks in the brooding house for ten weeks is more important to poultrymen keeping breeding flocks than to those keeping commercial pullets The reasoning behind this is not from a brooding standpoint, but because it is much better to move the birds to their permanent laying quarters at a young age in order to prevent stress and possible "breaks" in the MG-clean or MS-clean status of the flock Such breaks occur more often when older birds are moved Thus, the birds *are kept in the brooding house longer, but moved to the laying house* earlier—at ten weeks of age

The Brood-grow House

The poultryman raising commercial Leghorns or medium-size, egg type pullets has found it more advantageous to use the same house for brooding and growing This eliminates one moving of the birds, creating less stress But the brood-grow house has found acceptance because a great many commercial laying pullets are moved to cages rather than to floor operations Pullets may be moved to cages at a younger age than when they are moved to a floored laying house Some operators will transfer the growing birds to laying cages when the birds are as young as 14 weeks, although more will keep them until they are 17 to 18 weeks of age

Floor space, feeding space, and waterer space should be adequate for birds just *prior to the time* they are moved from the house Do not allow crowding at the feeders or waterers as the birds grow older

Grow lay House

When birds to be used later as breeders are moved to the permanent laying quarters at 10 weeks of age, the laying house becomes a growing house for about 12 to 14 weeks In order not to duplicate any feeding and watering equipment it should be of a size adequate for laying birds So-called small-size growing equipment is not to be used in these houses

Number of birds to place in house First determine the number of mature pullets and cockerels the house will accommodate, then add the number of culls and dead birds expected between 10 weeks of age and maturity This total will represent the number of birds to be placed in the house at 10 weeks of age

Remember Do not move birds from house to house or from pen to pen Birds placed in the building at ten weeks of age should remain in the same pen until the end of their laying period

Brood-grow-lay House

Another accepted housing practice, particularly among those poultrymen keeping breeding birds, is to confine the birds to the same house from one day of age until the end of the laying year. Such a house is known as the *brood-grow-lay* house, to be used for brooding, growing, and laying. Necessarily, equipment must vary according to the age and requirements of the birds as they grow older.

Ventilating this type of building must have special consideration because of the different needs associated with bird age. Usually this presents few problems, as the house must be designed for proper ventilation when filled with mature birds. As a result, the air movement will be ample for younger and smaller fowl.

Isolation of Houses

All houses, or groups of houses containing birds of the same age, must be isolated. For better security, a fence should surround the house or houses. Separate caretakers should be employed at each unit; no one should be allowed to go from one unit to another unless he properly showers and changes into clean clothing.

Cleaning the Growing House

Regardless of the age at which the birds are to be moved from their first home, the new quarters should have been completely cleaned and disinfected prior to the time the birds are admitted. Follow the cleaning directions for poultry houses as given in Chapter 13.

Use clean litter Add clean litter to the house to which the birds are to be moved. Although some poultrymen have "seeded" new litter with old as a method of producing some resistance to Marek's disease, the advent of Marek's disease vaccines has made this program obsolete. Also, such a procedure may cause the appearance of other diseases caused by organisms found in the old litter.

Caution New litter contains no coccidia oocysts, therefore a watchful eye for coccidiosis symptoms will be necessary after the birds are placed in the new house. Although coccidiosis should not be evident in the new house unless the birds are in the midst of an attack when moved, oocysts soon build up in the new quarters, and coccidiosis may hit suddenly. Be ready to medicate immediately.

Growing House Capacity

The amount of floor space needed by different strains and ages of birds is highly variable. Breeders selling the respective lines should be consulted regarding their recommendations. However, averages for birds on littered floors are given in Table 14.1.

The floor space suggested in Table 14.1 is based on the requirement at growing maturity, or for the week designated. Although birds require less floor space when younger, it is unwise to allow for anything but maximum needs. However, in instances where birds are to be moved from the house at an early age, e g , at ten weeks, more birds may be raised in a given area.

TABLE 14 1

FLOOR SPACE REQUIREMENT FOR GROWING BIRDS
(Littered floor)

Line and Sex	Floor Space per Bird		Birds per Sq M
	Sq Ft	Sq M	
Leghorn, egg type pullets			
to 18 weeks	1 3	0 12	8 3
to 22 weeks	1 75	0 16	6 2
Medium size, egg type pullets			
to 18 weeks	1 7	0 16	6 3
to 22 weeks	2 0	0 19	5 4
Leghorn breeder pullets	2 0	0 19	5 4
Leghorn breeder cockerels	2 0	0 19	5 4
Medium-size breeder pullets	2 2	0 20	4 9
Medium-size breeder cockerels	2 5	0 23	4 3
Meat type, breeder pullets	3	0 27	3 6
Meat type, breeder cockerels	4	0 37	2 7

Slat-and-litter house floor space Floor space requirements for birds in a house with a slat and littered floor are about 75% of those given in Table 14 1

All slat house floor space When an all-slat house can be used, the floor space requirements are approximately 60% of those given in Table 14 1. *Remember*, all-slat houses are not recommended for some breeds and lines of chickens

MANAGEMENT SUGGESTIONS

Special management procedures are necessary during the growing period. These are numerous and mandatory if good pullets are to be raised Most of these suggestions are precautionary measures, trouble is to be averted rather than treated

Selection of Breeder Birds at Six to Eight Weeks

Most breeding organizations require the exertion of *selection pressure* when breeding birds are six to eight weeks of age, particularly in the meat-type lines, and more so for the males than for the females *The program calls for starting* more day-old chicks than will be necessary in the breeding pens Some of these *extras will be used as replacements* for birds that die during the growing period; but more important is having them ready to use as replacements *for undersized* birds which will be culled to improve the growth of the offspring.

Selection of meat type lines There is a close correlation between weight of meat-type parents at six to eight weeks of age and the weight of their broiler offspring Therefore, there must be a weight selection at the end of the brooding period As there is little *correlation between body weight* at sexual maturity and the weight of the broiler offspring, the weight selection cannot be made when the birds go into the laying pens

More pressure usually is placed on the males than the females, although there is no difference in the effects Because there are fewer males than females, it is more economical to cull the males than the females See Chapter 22

How to select males First it is necessary to know the percentage of the males started to be retained at 6 to 8 weeks of age. This figure can be supplied by the genetic breeder Next, use a poultry catching screen and catch and individually weigh a minimum of 10% of the males in *each pen.* The sample must be representative. On a sheet of paper, record the weights in order from the heaviest to the lightest. Using the percentage figure of the males to be kept, count this number off starting with the heaviest and working toward the lightest. The figure at which the percentage is reached will be the minimum weight for males in the pen to be kept. Next, individually weigh all males and discard all below the minimum established weight *Remember* that there will be weight variations among the pens in the house, thus sample weighings must be taken in every pen, and a minimum body weight established.

How to select females Most breeders do not stipulate that selection pressure for body weight be exerted on the females, but some do. If the latter is the case, a procedure identical with that used to process the males must be followed

Selection of egg-type lines Inasmuch as 6-to-8-week selection is made to improve the weight of the offspring, there is no reason for following the procedure with egg-type breeder or commercial lines, weight is not involved here. Only inferior birds should be removed at a young age, and it is better to wait until the birds are 10 to 14 weeks of age before removing any inferior ones

Remove inaccurately sexed birds Most breeding procedures involve the mating of males and females from separate lines of birds Chicks from each line must be sexed at one day of age There will be inaccuracies, and some pullets will be found with the cockerels and some cockerels will be found with the pullets. These *sexing errors*, as they are called, must be removed prior to making up the matings As these are costly to keep around, they should be removed as soon as possible and discarded, or sold as broilers, depending on the strain.

If the sexes have been raised together, it will be impossible to determine the sexing errors as there will be both males and females in the same pen To be able to remove sexing errors in mixed flocks, the hatchery must identify the males and females This may be accomplished in several ways·

(1) Dub the males
(2) Toe clip one sex or the other.
(3) Toe clip each sex differently

Example If procedure (1) is followed and a dubbed female appears, it is obviously a sexing error.

Waterer Space

As chicks grow older they require more waterer space The requirements during the growing period are governed by the need when the birds reach sexual maturity. These requirements are given in Table 14.2 It must be remembered, however, that with older birds being raised during periods of hot weather, these suggestions may not be ample Birds will drink much more water when the temperature is at

TABLE 14.2

WATERER SPACE FOR GROWING PULLETS AND COCKERELS
(6–22 weeks of age)

Type and Sex	Automatic Troughs or Regular Troughs per Bird In.	Cm	Per 100 birds: 8 ft (2.4 m) Troughs	Large Pans*	Cups	Drip type Nipples
Leghorn pullets and cockerels	0.75	1.9	0.38	1	7	10
Medium size pullets and cockerels	0.85	2.2	0.43	1.1	8	11
Meat type pullets	1.00	2.5	0.50	1.3	9	12
Meat type cockerels	1.25	3.2	0.63	1.6	10	13

* A large pan has a circumference of 50 in. (127 cm)

100°F (37.8°C) than they do at 70°F (21.1°C). Be certain that there is no crowding around the water containers.

Feeder Space

As with waterer space, feeder space requirements during the growing period must be adequate for mature birds. However, if the chickens are moved from the house prior to maturity, the necessary feeder space is proportionately less.

Feeder space and feed restriction. More and more, poultrymen are using a controlled feeding program that involves restriction of the feed during the

TABLE 14.3

FEEDER SPACE FOR GROWING PULLETS AND COCKERELS
(6–22 weeks of age)

Type of Bird	When Cockerels and Pullets Grown Separately: In. per Bird	Cm per Bird	Large Tube Feeders per 100 Birds*	When Cockerels Grown with Pullets: In. per Bird	Cm per Bird	Large Tube Feeders per 100 Birds*
Leghorn, egg type pullets	2.5	6.4	3	—	—	—
Medium-size egg type pullets	3.0	7.6	4	—	—	—
Leghorn breeder pullets	2.5	6.4	3	2.5	6.4	3
Leghorn breeder cockerels	3.0	7.6	4	2.5	6.4	3
Medium size breeder pullets	3.0	7.6	4	3.0	7.6	4
Medium size breeder cockerels	3.5	8.9	5	3.0	7.6	4
Meat type breeder pullets	4.0	10.2	5	4.0	10.2	5
Meat type breeder cockerels	5.0	12.7	6	4.0	10.2	5

* A large tube feeder has a pan with a 50-in. (127-cm) circumference

growing period. This program calls for more feeding space, since it is necessary that all the birds have room enough to eat once the day's feed allotment is provided. Thus, the recommendations found in Table 14.3 are greater than those made a few years ago. It is very important that there be plenty of feeding space when feed restriction is practiced. When it is inadequate, the birds will lack uniformity when mature because the aggressive birds will have eaten more feed than the timid ones.

Feeder Height

During the growing period, adjust the height of the feeder so that the bottom is 1 in. (2.5 cm) higher than the backs of the birds. When the level is lower, birds will beak out more feed, a direct waste and expense. It should be easy to change the height of the feeders. Adjustable legs, suspension-type chains, or cables will be necessary. Many suspended feeders are quickly regulated with a cable and winch, thereby moving all feeders in the house at one time.

Feed Level

There should be only a small amount of feed in the feeders. In automatic feeders the depth should never exceed 1 in. (2.5 cm), and even less may be practical to prevent feed wastage. Conventional troughs should be kept about one-third full.

Restricted Feeding Precautions

If feed restriction is practiced, extreme care should be taken to provide the day's feed supply so that all birds get an equal chance to eat. With automatic feeders this is difficult, as the birds nearest the feed hopper get the first feed and may eat so much that there is little left for those at the end of the house. If the feeder loops the building, birds will eat more readily from that portion of the trough or from pans nearest the feed hopper; few will eat in the section at the end of the loop, even though it is in the same end of the house. To overcome the problem, there are available tube-and-pan-type feeders that drop feed in the pans at one time, thus giving the birds in all sections of the house an equal opportunity to eat simultaneously.

Overcoming the problem: With the conventional automatic feeder, feed must be available in all sections of the trough, or all pans, when the birds arise in the morning. This will necessitate filling the feeders after dark, and starting automatic feed delivery as soon as the birds begin eating in the morning.

Problem accentuated when pens are used: If the house is divided into pens, the problem of providing an equal amount of feed in all pens is even more pronounced with automatic feeders. The birds in the pens nearest the hopper will get most of the feed, leaving less for those in the end pens. Under such circumstances, it is almost mandatory that the feeders be filled at night, with feed available in all pens when the birds arise.

Check to see if there is a feed distribution problem: Uneven feed distribution in the house creates a severe stress on many birds and leads to poor uniformity of body weight. This can become serious within the house, or from pen to pen, particularly when a restricted feeding program is being

used It is not enough to know only that the feed consumption for the entire house is correct, but it must be correct for each segment of the house or each pen Careful observations should be made to get the answer

(1) Is there feed in the return portion of the automatic feeder trough, or, are all pans full?
(2) Are the birds frequenting one section of the automatic feeder trough, or of the pans, more than others?
(3) Is the average weight of the birds uniform throughout the house, or in each pen?
(4) Is *uniformity* of body weight identical in different sections of the house or in each pen?

How to feed when feed restriction is practiced Feed restriction implies reducing the feed intake every day, or skipping feeding on one or more days of the week Regardless of the system used, the daily feed allotment is to be weighed for accuracy, then the entire amount must be fed until it is all consumed Automatic feeders should be operated continuously until the allotment is eaten

Make sure of this Do not run the automatic feeder intermittently when restricted feeding is followed If the birds are being hand fed, never allow the feeders to become empty until the day's feed allotment is consumed

Here's why When restricted feeding is practiced, the noise from the motorized feeder and the appearance of feed in the troughs or pans cause the birds to rush to the feeders Obviously, the larger and more aggressive birds will eat first However, as soon as they are full, they will leave the feeder, allowing the smaller and more timid birds to get their fill, provided there is feed available When the entire allotment of feed is given at one time, the timid birds eventually will get their full feeding, but if several feedings are made, the larger birds get most of the feed each time, leaving little for the smaller birds

How to feed when full feeding is practiced When birds are hand fed, feed should be kept before them at all times *To keep a low level of feed in the troughs*, feed must be added to the feeders two or three times a day But when automatic feeders are used for full feeding, the feeders should be operated intermittently Run them approximately 20 minutes, then allow them to remain idle for 20 minutes, then run again, etc The exact on and off time will be determined by the length of the house and the amount of feed in the trough or pans at the end of the period when the feeders are not operating Some feed should be *in the troughs at all times* As automatic feeding equipment is operated from a time clock, settings may be made for any time interval

Another reason Running the automatic feeding equipment *intermittently* reduces the wear on the troughs, chains, augers, gears, *etc*, as it operates about half the time

GROWING HOUSE ARRANGEMENT

The arrangement of the equipment within the poultry house can have a great bearing on one's ability to raise a good pullet or cockerel. Many times the location of interior items will necessitate special consideration in an endeavor to train the birds to use the equipment.

Type of Floor

The type of floor in the growing house will vary the management recommendations. Littered, part slats, part wire, all slats, all wire, and other floor innovations are used for growing pullets and cockerels.

Littered floor: If the floor is completely covered with litter, the equipment should be evenly distributed throughout the house. No bird should have to go more than 10 ft (3 m) for feed or water. Consumption of both is greater when the distance is short, and stress is less. Furthermore, birds congregate in groups within the house or the pen, and each group does its eating and drinking within a relatively small area: birds dislike going to an area with which they are not familiar. See Chapter 22, Social Order. In a narrow house, the automatic feeders are placed lengthwise of the house, with the waterers in between. In a wide house the equipment should have greater distribution. Short, conventional troughs should be placed crosswise of the house.

Slat-and-litter floor: When a portion of the floor is covered with slats, young birds must be trained to frequent the slat area. Even after they can jump on the slats, they may not use them, particularly if the feeders and waterers stay on the littered part of the floor. In most houses of this type, however, the automatic feeders and automatic waterers are placed on the slats. Prior to about eight weeks of age all feeding and watering must be done on the littered portion of the floor. When they reach eight weeks the automatics on the slats should be placed in operation. As the birds begin to drink and feed from the automatic equipment, gradually remove the feeders and waterers that are on the litter. But do it slowly. There will be a few backward birds that will not learn the new location easily, and it is best to leave a few feeders and waterers on the litter floor for some time. Similar recommendations are made if wire replaces the slats.

At first the birds will bed down on the litter at night, but as they get older all should roost on the slats at night.

All-slat floor: In many instances, particularly with egg-type commercial pullets, the growing birds are moved from the brooding, or the brood-grow unit, to a house having slats over the entire floor area. Usually these houses do not present as many management problems as those with a slat-and-litter floor. The birds may be frightened at first, and precautions should be taken to see that there is no crowding or piling. Watch the birds the first few nights. Slats are cooler at night than a littered floor, and the birds may pile in their endeavor to keep warm.

Cages: Cage management is discussed fully in Chapter 17. This section must be read thoroughly if birds are grown conventionally and then moved to some type of cage.

Waterers

Although most poultry waterers are now of an automatic type, operating from a valve to keep a constant water level, some poultrymen use running water A "V" shaped trough is installed the length of the house, and the trough has a slight drop so that a stream of water runs through it continuously These are very satisfactory, for it has been shown that birds consume more water when it is fresh and running constantly than when it remains in a waterer But the proper location of these troughs is an important consideration They should not be placed outside the house so that the birds must reach through slats or a fence to get a drink, unless the water is shaded The hot rays from the sun will heat the water, reducing consumption Furthermore, it is too great a distance from the center of the house to the outside edge, birds should not have to travel this far to get a drink

How much water? With all "V"-shaped troughs, the depth of the water should be very slight, perhaps not over 0 5 in (1 3 cm) When there is little water in the trough the birds will keep the trough clean as they move their beaks in the trough to get a drink Similarly, they also will keep the feed out of the troughs When the water is too deep, dirt and debris accumulate at the bottom of the trough, and molds may grow on the sides

Changing Type of Surroundings

Chickens dislike changes in their day to-day routine, and care should be taken to see that the birds adjust quickly to any new equipment or to new surroundings Moving birds from house to house creates a stress, but new types of waterers or feeders add to the difficulties In the new house be sure that feed and water are easily available, and not in some location to which the birds are unaccustomed In some cases it may be advisable to provide open pans for a few days Place water in some, feed in others

Roosts

Growing birds do not require roosts, regardless of the breed or type But the lack of conventional roosts may pressure the birds into using other objects to sit on Avoid high objects if possible If not, then place antiroosting guards where birds may have occasion to sit

SPECIAL MANAGEMENT PROCEDURES

There are many requirements for the production of a good, mature pullet or cockerel The exceptional manager has these on his agenda, and is constantly observing the flock so that program changes may be made as needed No two flocks are identical, no two flocks will require the same procedures

Ventilating the Growing House

Growing birds must have an ample supply of fresh air, without drafts House ventilation has been discussed in detail in Chapter 11, but it should be brought out here that growing chickens do not do well in environmental extremes They feather poorly, growth is reduced, birds are not uniform, and feed conversion deteriorates—each a costly factor

Hot weather problems When the temperature gets above 80°F (26 7°C), chickens begin to suffer The higher the temperature, the greater the

stress Usually the first hot period of the season is the most disastrous, birds are not accustomed to the heat, and cannot adjust to differences in water and feed consumption to offset the high temperatures But be ready for the first heat wave, do not wait until the period is in progress Equipment for cooling the house and the birds should be operational when the heat strikes Fans, foggers, roof sprinklers, used to help cool the open-sided or conventional house, should be ready Provide plenty of cool, fresh water If the number of waterers was adequate for only cool weather, provide more as the weather begins to warm, before any extremely hot day

If environmentally controlled houses have been constructed properly, the advent of hot weather should not cause serious repercussions Thermostats should cause the fans to operate more, causing a greater amount of air to flow through the building In many instances, however, the intake opening, or intake slot will have an adjustment for hot weather Be sure the change is made prior to any heat wave Any cooling devices, such as evaporator pads, should be started with the advent of warm weather, and be in full operation when the weather gets hot

Cold weather problems During cold weather, proper ventilation of the growing house may become difficult It will be necessary to conserve heat within the house without creating too high a level of moisture and ammonia Insulation, ventilating fans to move air in controlled amounts through the house, and dry litter aid in keeping the environment as near optimum as possible The open sided house will need closing, fans will be necessary to move the air through the house Be sure the building contains a maximum number of birds in order to produce the greatest amount of body heat

The environmentally controlled house offers a better means of creating a good environment for growing chickens during cold weather It will be tight and adequately ventilated to conserve heat, yet still maintain a low level of humidity and ammonia But because growing birds increase in weight each week, the ventilating requirements will vary accordingly Be sure to make the necessary adjustments

Litter Management

The poultryman who can manage his litter will prevent a great many of his problems During the growing period litter should contain between 20 and 30% moisture There are several reasons

(1) Feathering is better
(2) Growth is closer to normal
(3) Feed conversion is improved
(4) The coccidiosis problem is more easily controlled
(5) Ammonia in the house is reduced

Determining litter condition Pick up a handful of litter and squeeze it tightly, then open the hand If the condition of the litter is correct, crevices should form in the compressed material, it should not form a cohesive ball nor fall away in a pile

Causes of changes in litter condition Many things affect the condition of the litter

(1) relative humidity and temperature of the outside air,
(2) relative humidity and temperature inside the poultry house,
(3) number, age, and weight of the birds in the building,
(4) amount of air moving through the house,
(5) water consumption of the birds,
(6) makeup and form of feed

Litter and coccidiosis control Probably the biggest reason for keeping a required percentage of moisture in the litter has to do with the control of coccidiosis See Chapter 41, Coccidiosis During the growing period it will be necessary to develop immunity to coccidiosis in the birds This calls for a gradual withdrawal of the coccidiostat used during the brooding period The withdrawal should begin when the chicks are about six weeks of age The directions call for taking 10 to 12 weeks to reduce the coccidiostat in the feed to zero The object is to allow immunity to build up a little more with each reduction of the coccidiostat Related to the development of immunity is the rapidity of sporulation of oocysts in the litter, closely associated with the amount of moisture it contains If the litter is too dry, sporulation is reduced and immunity is slow to develop If it contains too much moisture, sporulation is rapid and the coccidiostat in the ration may not be adequate to suppress coccidial damage of the intestinal tract

Wetting the litter During extremely dry periods, when the litter gets too dry, it may be advantageous to sprinkle it with water to raise its moisture content and to better control the sporulation of oocysts *But be careful* If the litter has been dry for some period, it will contain billions of unsporulated oocysts Wetting the litter will cause a great number of oocysts to sporulate, and if there is a limited amount of a coccidiostat in the feed, a severe attack of coccidiosis may be initiated It is better to wet the litter a little each day during dry weather than to wait and try to restore its moisture content in one application In any event, whenever water is added to litter, be ready to treat for coccidiosis should an outbreak occur

How to gauge coccidiostat withdrawal Withdrawal of a coccidiostat from the feed in order to establish natural immunity in the birds is most difficult Considerable experience is necessary, as the only index of exactness is an observation of the birds, and a careful observation must be made every day To attain immunity through withdrawal of the coccidiostat, the birds must develop a little coccidiosis When they do not, the chances are great that no immunity is being developed But too much coccidiosis can be disastrous, precipitating great morbidity

Important Be ready to treat for coccidiosis when a withdrawal program is in progress A water-soluble coccidiostat should be readily available, and then used quickly in the drinking water

Wet spots around waterers Birds will spill some water when drinking and the litter around the waterers may become extremely wet Oocyst sporulation is increased in this area of the house, and may be great enough to cause an increase in the incidence of coccidiosis Remove the wet material, and check to see that the water level in the waterers is low

Be sure any automatic water valves are working properly and that waterers are not overflowing

Coccidiosis control when layers are to be caged When birds are grown on a littered floor, but are to go into cages or on a wire floor during the last part of their growing period or at sexual maturity, some change in the coccidiosis program will be necessary Immunity should be developed prior to the time the birds are placed on wire If it is not possible to do this, or the degree of immunity is not known when the birds are caged or placed on a wire floor, continue to feed some coccidiostat for three or four weeks Too often poultrymen feel that caged birds will not get coccidiosis, but this is true only when chickens are kept in cages from one day of age Birds transferred from a littered floor to a wire floor will be loaded with sporulated oocysts, and if the feed used after the the birds are placed on the wire contains no coccidiostat, or immunity is not complete, coccidiosis will develop, sometimes seriously

Coccidiosis when birds are on slats Birds may develop severe attacks of coccidiosis when they are kept on slats They have access to enough sporulated oocysts through the droppings that stick to the slats to cause an outbreak Manipulate the coccidiosis control program accordingly, using a coccidiostat in the feed, then withdrawing it gradually to develop immunity

Managing the CocciVac program When this method is used to develop immunity to coccidiosis, most of the precautions necessary when a coccidiostat is placed in the feed will be needed on the CocciVac program There is no foolproof procedure *Remember* that no coccidiostat is to be fed when CocciVac is used (See Chapter 41, Coccidiosis, for complete details), but always be on the watch for outbreaks Treat when necessary

Sanitation

Sanitation during the growing period is just as necessary as during any other age of the bird Keeping things clean requires a daily vigil Isolation of the growing house, showers, clean clothing, separate caretakers, daily cleaning of waterers, proper litter, clean feed, etc , are all parts of the sanitation program Daily routine to keep the premises sanitary should be detailed and written in advance, and the program should be carried out to the letter Half a job is little better than no job at all Stress and disease do not operate in this manner, usually they are either all or nothing See Chapter 43 for recommendations for preventing disease

MG and MS Testing Procedure

A high proportion of those farms engaged in the raising of breeding stock are now on a program to prevent *Mycoplasma gallisepticum* or *Mycoplasma synoviae* from gaining entrance to the birds Flocks are blood tested every 4 weeks during the growing period, beginning when the chicks are 8 weeks of age and continuing until they enter the breeding laying pens About 5% of the birds are to be tested in each house or pen every 4 weeks Local regulations will determine whether the tube or plate test is to be used Complete isolation of the growing house, along

with strict sanitation, should cause the flock to remain free of the disease See Chapter 41, MG and MS

What to do when reactors appear When reactors to the MG or MS blood test appear, the flock has "broken" and *the birds have had the disease* Many will remain as "carriers," transmitting the organism through the hatching egg to the day-old chick If the hatchery to which the hatching eggs from this flock were to be shipped has a clean status, eggs from this flock cannot be used for incubation unless they are preheated If all other flocks on the farm are clean, the diseased flock should be moved *off the* farm immediately to prevent it from contaminating clean birds in other houses *But before any infected birds are moved, take some to the laboratory for a confirmation of the blood test*

Infected flocks may be used for the production of eggs for human consumption, but the birds should be moved to a new location if there are other birds with a clean status on the original farm

Worm Control

If worms have become a problem, some procedure for keeping them under control should be initiated See Chapter 42 But do not spend money on unnecessary worm-control programs Be sure you have an accurate diagnosis of the type of worm involved Consult a recognized veterinarian and discuss treatment with him

Rodent Control

Rats and mice cause a heavy economic loss They consume a great deal of feed, and create a general nuisance They are extremely prolific, the premises soon can be overrun with them When the presence of rodents is obvious, begin a program of elimination immediately See Chapter 42 for details for the control of rats and mice on a poultry farm

Vaccination Program

Most vaccination programs begin during the brooding period, although some Marek's disease vaccines may be administered in the hatchery But vaccinations also continue during the growing period The program should have been determined before the arrival of day-old chicks on the farm, then each vaccination given on a specified date Do not neglect the necessity of keeping on a schedule during the growing period Most failures from vaccination are managerial mistakes The vaccine was old, improperly kept, administered incorrectly, at the wrong time, or was not necessary Be sure you have consulted an authority for the best program of developmental immunity in your area See Chapter 43 for suggestions regarding this

Check for immunity status Just to vaccinate is not enough An appraisal of the immunity developed should be made This usually involves taking titers on the blood to see if an adequate number of antibodies developed as the result of the vaccination See Chapter 39 *Contact a laboratory that can run these determinations and give you the information you need for your disease-control program*

Disease Diagnosis

In spite of all the precautions taken on a poultry farm, disease and trouble will occur at times In many instances a medication program is available to treat the

difficulty. *But be sure you know what the difficulty is.* Take 5 or 6 typically involved birds to a good disease diagnostic laboratory. Once the trouble is identified, discuss remedial measures. But act *promptly; trouble is more difficult to* cope with the longer it is present.

Double-check medicament dosages: Read the instructions carefully, particularly as they apply to dosages. Many mistakes have been made because the birds were overtreated or undertreated. Be sure the drug is one approved for use by the government or other regulatory agency. Know the withdrawal period for the medicament, i.e., how long its use must be stopped before birds are to be slaughtered for consumption.

Debeaking the Pullets

Although six-to-nine-day debeaking is gaining more acceptance, other ages and other methods are used by many poultrymen, particularly those involved with the raising of egg-type birds.

10-14-week debeaking: With commercial Leghorns and birds laying brown eggs for market, some prefer to debeak pullets at 10 to 14 weeks of age. When picking occurs earlier than this, the birds are debeaked as soon as the symptoms are observed. With an electric debeaker, cut the upper and lower beaks about 3/16 to 1/4-in. (0.45-.63 cm) in front of the nostrils. With older birds it may be necessary to cut one beak at a time. In such a case cut the lower slightly longer. Cauterize the cut area thoroughly, and round the corners.

Caution: Be sure
- not to debeak during a vaccination period;
- to supply feed immediately after debeaking;
- to increase the level of both feed and water after debeaking;
- to debeak during the cool part of the day;
- to add vitamin K to the ration during hot weather;
- to catch a small number of birds at one time;
- to debeak males about half as much as the females.

18-week debeaking: As in debeaking at 10 to 14 weeks, birds may be debeaked 3 or 4 weeks prior to egg production, but do not remove as much of the beak. The lower beak of pullets should be a good 1/8 in. (0.32 cm) longer than the upper. Cockerels to be used in the breeding pen should have the tips of their beaks clipped. Cut into the "quick" area but slightly. Follow the precautions given for 10-14-week debeaking.

Specs to Prevent Picking

Specs provide a means of preventing birds from picking each other. There are several types available, but all are held on by inserting a pin through the nostrils. Specs may be applied without problems at any age after about ten weeks and before the birds begin laying eggs. Extreme care should be used when applying them to pullets in production for they tend to depress feed and water consumption until the birds get used to them. Attach specs to a small group of layers first to see the reaction. Specs may also be used on cockerels, but not guards that hang over the end of the beak.

Important: When layers are placed in cages many pullets will catch their specs on the wire partitions and pull them off, requiring replacement at

regular intervals, a costly procedure A special guard is available for cage use Debeaking is a much better method of preventing picking when birds are to be caged Do not debeak and spec the same bird unless absolutely necessary

Housing Males and Females

When breeding males and breeding females have been raised separately it will be necessary to place them together at some time prior to egg production This may cause some problems, the magnitude of which will be related to their color and age.

Males and females of a different color Breed crosses are often used in the course of producing pullets capable of laying brown shelled eggs Often a Rhode Island Red male is mated with a Barred Rock female, each having a different color, and the difference will frighten one sex or the other, or both The birds may not eat or drink, and they may crowd and pile To overcome this, place the males in a small enclosure within the pen holding the females and keep them there for several days, feeding and watering each sex separately

Males at sexual maturity Once sexual maturity is reached, males within a group will begin to fight The difficulty is accentuated when sexually mature males are placed with females for the first time, because the males have more difficulty in establishing their social order As this requires fighting, injury or the loss of many males may result When mature males are placed with mature females, place the necessary number of males in the pen about two days prior to moving in the pullets The male social order will be consummated with but little fighting before the arrival of the females

Special Male Growing Procedures

Dewattling Breeding males should be dewattled during the growing period to prevent the wattles from being torn by fighting, and to make it easier for the males to feed and drink During the cool part of the day take a medium-size set of scissors and cut off each wattle at the feather line, about 1/8 in (0 3 cm) from the head Birds should be from 12 to 14 weeks of age There should be little bleeding, except during hot weather Vitamin K may be added to the ration for four weeks before and for four weeks after dewattling to help reduce the hemorrhaging If males are with females at the time of dewattling, place the males in a fenced enclosure in the same pen until the wattles heal, to prevent females from picking at the cut area

Toe clipping older males Although clipping the inside and back toes of males is recommended when they are day old or shortly after, at times the operation is neglected and cockerels reach maturity with normal toes In such cases the inside and back *toenails* must be clipped, prior to the time mating starts With an electric debeaker, cut the inside and back toenails at the root of the nail Remove them from the hot blade imme diately to prevent burning the tissue As an alternate method, heavy shears may be used

Weekly Culling During Growing Period

Inferior, crippled, injured, and deformed birds should be removed from the flock during the growing period. In all probability these birds will do poorly when egg production begins, and to keep them in the growing pen only adds to the expense of producing good pullets. But do not catch the entire pen or house of birds to remove these few. Use a catching hook and remove them quietly one day each week. Be sure to make an accounting of the number removed on the house record sheet.

FEEDING DURING THE GROWING PERIOD

Proper nutrition during the growing period is extremely important. A full discussion is given in Chapters 25 through 35, and the subject should be thoroughly understood. Not only is a balanced ration necessary, but how the feed is fed and how much is fed are just as important. Great changes have taken place in feeding procedures during the past few years and the ability of the poultryman to keep himself informed of the latest recommendations is very important if he is to raise a good pullet or cockerel.

A few years ago it was thought that growing chickens would do well if given all of a balanced ration they would eat. But self-feeding during the growing period has become obsolete with those raising meat type birds, and is gradually gaining some disfavor in the production of egg type pullets. When growing chickens are self-fed, they eat more feed than they actually need. They gain too much weight during this period, and this is a detriment when they go through their laying cycle. Furthermore, by restricting the growing feed intake, reductions are made in the cost of producing a pullet. But feed restriction has no definite formula. The amount of feed restriction must be correlated with the weight of the growing bird. Thus, feed intake must be *controlled*, and the system is known as *controlled feeding*.

Controlled Feeding and Body Weight

Breeders of meat-type and egg-type birds have completed a great deal of research to establish the optimum weight of their pullets at the time they begin egg production (sexual maturity). Attaining this weight is necessary if the birds are to lay, live, and produce well during the egg production period. In the case of meat-type birds, body weight at sexual maturity should be about 20 to 25% less than the weight attained had the birds been full fed. The precise amount will vary with the strain of bird. Egg-type strains present a somewhat different picture. Having a small digestive system in comparison with their size, they do not tend to get overly heavy. Most strains may be full-fed during the growing period, with seemingly good results during the laying cycle. Others do much better if their weight at sexual maturity is reduced by 10 to 15 percent. All genetic breeders do not make this suggestion. However, do not let Leghorns get heavier than the weight recommendations.

Weekly weight recommendations. In order to reach a recommended body weight that is lower than normal at sexual maturity, it is necessary that weight reduction take place throughout the entire growing period. Theoretically this reduction should start the first week, but this is impractical, because chicks are full fed during the first six weeks. Therefore, the feed

restriction programs usually start the seventh week Those genetic breeders who develop the birds have produced charts which show the optimum body weight each week during the growing period, so that the birds will reach the proper size at sexual maturity As there is a great deal of difference in the makeup of feeds, it is impossible to program the amount of feed necessary each week to meet these standards Furthermore, other factors such as environmental temperature, hours of natural daylight, type of housing, and amount of floor space per bird will influence the figure The program of controlling body weight is up to the caretaker If, at some time during the growing period, the birds are too heavy, the feed allocation must be reduced If the birds are too light, more feed must be given

Weighing the growing birds Average flock body weights must be established once each week during the growing period This is of the utmost importance if a good pullet is to be raised But all birds need not be weighed Weigh approximately 10% of the birds in each pen within the house Do not weigh birds in one pen only, birds in each pen will vary in weight Then calculate the average weight for the entire house If there are no pens, weigh birds from several areas of the house

How to use weekly weights Establishing average weekly body weight is necessary to determine whether the birds are growing according to a predetermined schedule Feed allocation is based on body weight, and adjustments must be made each week, one cannot wait until the end of the growing period to decrease or increase the body weight by giving less or more feed Changes cannot be made that quickly, the recommended weights must be attained each week starting with the seventh week

Feeding Grit

Although grit is not a feed, it is eaten by the bird Grit is used by the chicken as a grinding material to help the gizzard break down large particles of feed into smaller ones The value of grit is debatable It should be fed if there are large particles of corn, wheat milo, or rice in the mash, and when chickens have access to litter or feathers, since it helps to grind any of these that the bird eats But when chickens are given a feed composed of fine material, no grinding action in the gizzard is necessary Although some experiments have shown that grit feeding will improve feed efficiency when broilers are grown, others have shown there is no benefit However, there is some indication that layers should have some grit during the growing period, even if they are raised on wire

How much grit? Chickens will consume tremendous quantities of grit if it is self fed, but only a small amount will be retained in the gizzard, the excess will be excreted When the birds are on a littered floor feed 1 lb (454 gm) of grit per 100 birds per week If on wire or slats feed one pound (454 gm) per 100 birds every six weeks Feed all the allowance on one day Never self feed grit over a long period

Caution When skip a-day feeding programs are being used, feed the grit on some day that feed is given *Do not feed the week's allotment of grit on a day when no feed is given*

How to feed grit: Grit is best fed from hanging tube feeders. Supply one tube feeder for each 250 birds. Do not use automatic feeders, as grit tends to lodge in the corners and, being an abrasive, it wears out the tubes, chains, and troughs.

Cockerel Feeders

In the past it was thought that when pullets were being raised on a controlled feeding program, which usually meant feed restriction, any males in the pen would not be getting enough feed. However, evidence points to the fact that males too should be on a controlled feeding program so as not to be overweight at the time they are used to produce fertile eggs. Thus, special feeders, known as *cockerel feeders* (tube feeders hung high enough so that the males, rather than the females, could eat from them) are seldom recommended. If however, the pullets in the growing pens are on a controlled, or limited, feeding program, and the pens contain both males and females, at times the males may be underweight. In such instances cockerel feeders may supplement the other feeders. Provide one tube feeder for every 20 cockerels in the pen. Pelleted feed or grain such as whole oats, cracked corn, wheat, or rice should be placed in the feeder. Males will not readily eat mash from a cockerel feeder. Keep feed available in the cockerel feeders at all times until body weight of the males is back to normal, then *gradually* cut back on the daily male feed allotment until the feeders are empty.

LIGHTING

Light, either natural or artificial, not only makes it easy for the birds to see to eat and drink, but it also affects the pituitary gland at the base of the brain, and the stimulation causes mature pullets to begin the production of eggs. The fact that the hours of natural daylight differ during the seasons of the year causes more pituitary activity during some months than others. When natural daylight is short, artificial light must be added. The procedure is complicated and warrants a special section. See Chapter 18.

In-season and Out-of-Season Birds

Pullets tend to come into egg production at a younger-than-normal age if they are grown under natural daylight during the time when daylight hours are lengthening. When the days get shorter, the onset of production is delayed. Those grown during the period when most of the days have decreasing light are known as *in-season birds*. Those grown when most of the days have increasing hours of light are known as *out-of-season birds*. These latter ones present growing difficulties:

(1) Brooding costs are higher in most areas.
(2) More feed usually is required because the birds are grown during periods of colder weather.
(3) Pullets mature earlier and lay smaller eggs at the start of egg production.
(4) Pullets lay at a lower rate and over a shorter period after they begin their production cycle.
(5) Birds are more difficult to raise during the growing period.

All the above factors necessitate special artificial lighting procedures to try to compensate for the deficiencies of natural daylight. Feed limitation also affects

the age of sexual maturity Thus, the feeding and lighting programs must be correlated so that a quality pullet will be produced—one that not only is good physically, but one that will begin to lay at a normal age

RECORD KEEPING

Keeping adequate records during the brooding and growing periods *is an essential* part of flock management Careful records inform one of what has happened in the past, and help one to plan for the future The house record should include the following

(1) line and source of chicks,
(2) vaccinations and medication (see Chapter 43 for an example of a form for recording these data),
(3) *feeding program used*,
(4) feed consumption, by days and weeks,
(5) body weight, by weeks after seven weeks,
(6) mortality, by days and weeks,
(7) culls, by days and weeks

Cost Records

Keep a record of the cost of raising the pullets and cockerels Feed, consumable supplies and labor are easily determined from accounting records Other costs may be allocated to get a total cost of raising a bird Moneys received for the sale of culls, manure, and early eggs should be credited back against growing costs

STARTED PULLETS

This chapter is attempting to show the complexities of growing a good replacement pullet for the production of commercial eggs Some farms do not have facilities for brooding and growing acceptable pullets At others the growing houses are too close to the laying units to provide ample isolation These and other factors have led certain poultrymen to confine their efforts to the brooding and growing of commercial, *egg type pullets, known as started pullets* Large numbers of birds are now grown by these specialists Pullets are sold to those requiring mature birds for their egg production program There are advantages and disadvantages for both the producer and the recipient of such pullets (flockowner)

Advantages to the Flockowner

(1) He can order pullets in advance
(2) Most vaccinations have been completed
(3) Birds have been grown on a farm where there were no laying pullets
(4) Growing risk has been eliminated
(5) Pullets usually are more uniform

Disadvantages to the Flockowner

(1) Started pullets usually are more expensive
(2) Sometimes pullets are too mature sexually
(3) Body weight may be too great
(4) Moving stress may be a complicating factor
(5) Disaster during growing could prevent delivery of pullets on schedule

(6) Some groups of pullets are better than others
(7) A large cash outlay is necessary at the time pullets are delivered The cash outlay is much less if the flockowner raises his own pullets; depreciation and some other factors are not cash expenses

Advantages to the Grower

(1) The grower is allowed to specialize
(2) He can make more efficient use of his buildings
(3) A better distribution of labor is possible.

Disadvantages to the Grower

(1) He must guarantee delivery of quality birds at a previously specified price
(2) Excessive mortality may offset any profit from the venture.
(3) Increasing feed and labor costs will lower profit
(4) The customer may refuse to take the mature birds for one reason or another, the grower is left with them

Have a Written Contract

To protect both the grower and the flockowner, a written agreement should be prepared and signed in advance by each party It should contain

(1) strain and number of pullets to be delivered,
(2) date and age of pullets at delivery,
(3) type of vaccinations, along with name of vaccine manufacturer,
(4) special services such as debeaking, dubbing, etc,
(5) feeding program involved during growing,
(6) price at time of specified delivery, and alternate prices for making delivery earlier or later,
(7) inspection of pullets by flockowner before delivery,
(8) type of crates used for delivery,
(9) who is to furnish delivery.

Contract Started Pullet Growers

Many started pullet growers have become big and no longer grow their birds on their own premises Rather, they contract others who have the facilities to grow the pullets for them The actual grower usually is paid at the rate of so much per square foot of floor space per week A bonus for doing a good job and growing a high percentage of the pullets started also may be given.

The contractor secures the orders, and finances the grower by furnishing the chicks, feed, vaccines, medicaments, etc., and pays for or provides the delivery In many instances these obligations are those of a feed manufacturing plant In others, they may be part of a larger integrated operation. But many people have separate pullet-growing businesses

Cost of Producing a Pullet

The cost of producing a salable pullet is highly variable, and differences as high as 40% are not uncommon. Feed price, labor cost, age at delivery, and mortality are the factors largely responsible for most of the variations.

Delivery age an important cost factor Most started pullets are delivered

when they are between 15 and 22 weeks of age, but 18 weeks is the most common Flockowners like to get pullets in their permanent laying quarters several weeks in advance of egg production But the cost of keeping the growing pullet longer is great—a factor often overlooked or not understood by producers In fact, it costs about 25 to 35% more to carry a pullet from 15 through 21 weeks of age

Livability an important cost factor The ability to raise a high percentage of the chicks started is an important cost item, and differences create great variations in the total cost of raising a pullet Pullets of poor quality at maturity are not easily sold, and even if they are, a distress price may have to be arranged One should certainly be able to deliver 90% of those started, many hit the 95% figure

Calculating estimated cost of producing a pullet Table 14 4 shows a method of calculating the estimated cost of growing a commercial Leghorn pullet

TABLE 14 4

COST OF PRODUCING A COMMERCIAL LEGHORN PULLET

Item	Cost
1 Female chick cost, delivered	$_____
2 Growing feed cost through 18 weeks (14 lb or 6 4 kg x $_____ lb/kg	_____
3 Growing labor $_____ per minute x 6 minutes	_____
4 Factor Facility depreciation cost 14% x Total feed cost (Line 2)	_____
5 Factor 28% x Total feed cost (Line 2)	_____
6 Cost to raise a pullet through 18 weeks (with no mortality) (Total Lines 1,2,3,4,5)	_____
7 % Factor to determine cost based on age sold and % salable (Select appropriate Factor percent from following table)	_____%

Age of Pullet Sold	*Salable Pullets as Percent of those Started*							
	95%	90%	85%	80%	75%	70%	65%	60%
Wks	Factor Percent							
15	93	95	98	101	104	107	110	113
16	96	98	101	104	107	110	113	117
17	98	100	103	106	109	113	116	120
18	103	105	108	111	114	118	121	125
19	107	110	113	116	119	123	126	130
20	112	115	118	121	125	129	133	137
21	118	121	124	128	132	136	140	144

Item	Cost
8 PRODUCTION COST PER STARTED PULLET SOLD AT _____ wks. and _____ % salable (line 6 x Line 7)	$_____
9 Cost to deliver each started pullet	_____
10 TOTAL COST PER STARTED PULLET SOLD (Line 8 plus Line 9)	_____
11 Profit per pullet sold	_____
12 *SELLING PRICE PER PULLET* (Line 10 plus Line 11)	_____

to various ages and with varying livability, when the unit feed cost and unit labor cost are known The table may be applied to those growing their own pullets or to those who have a started pullet program The factors given represent *average* figures If the operation is especially efficient or drastically inefficient, adjustments will have to be made in the formula Table 14 5 is to be used for medium size commercial pullets, such as those used to produce brown eggs for human consumption

Transporting Started Pullets

Started pullets are transported over distances up to several hundred miles with little, if any, difficulty They are placed in coops, then hauled by trucks A tarpaulin should be placed over the front of the coops during warm weather to act as a windbreak During cold or wet weather it should be extended over the top and down across the sides to give added protection

Tranquilizers at catching time Started pullets are easily frightened when

TABLE 14 5

COST OF PRODUCING A COMMERCIAL MEDIUM SIZE PULLET

Item	Cost
1 Female chick cost delivered	$____
2 Growing feed cost through 18 weeks (16 lb or 7 2 kg X $____ lb/kg)	____
3 Growing labor $____ per minute X 7 minutes	____
4 Factor Facility depreciation cost 16% X Total feed cost (Line 2)	____
5 Factor 24% X Total feed cost (Line 2)	
6 Cost to raise a pullet through 18 weeks (with no mortality) (Total Lines 1,2 3,4 5)	____
7 % Factor to determine cost based on age sold and % salable (Select appropriate Factor percent from following table)	____%

Age of Pullet Sold	Salable Pullets as Percent of those Started							
	95%	90%	85%	80%	75%	70%	65%	60%
Wks	Factor Percent							
15	93	95	98	101	104	107	110	113
16	96	98	101	104	107	110	113	117
17	98	100	103	106	109	113	116	120
18	103	105	108	111	114	118	121	125
19	107	110	113	116	119	123	126	130
20	112	115	118	121	125	129	133	137
21	118	121	124	128	132	136	140	144

8 PRODUCTION COST PER STARTED PULLET SOLD AT ____ wks. and ____ % salable (Line 6 X Line 7)	$ ____
9 Cost to deliver each started pullet	____
10 TOTAL COST PER STARTED PULLET SOLD (Line 8 plus Line 9)	____
11 Profit per pullet sold	____
12 SELLING PRICE PER PULLET (Line 10 plus Line 11)	____

disturbed at catching time *Tranquilizers* may be given the birds just prior to catching to keep them docile There are several on the market

Careful handling Pullets should be handled carefully at the time they are moved Severe damage may be encountered with rough treatment

Transportation diarrhea Most started pullets develop a laxative condition when they are moved The wet droppings in the crates soil the plumage during moving, giving the birds a very unsightly appearance Tranquilizers will stop most of this, careful handling will help control it further. Eliminate all possible stress

Special moving precautions

(1) Do not mix birds of different lines and ages
(2) Do not create a stress by debeaking birds during the period ten days before to ten days after moving
(3) Provide extra waterers and feeders when pullets are placed in permanent laying quarters Beware of changes in types of waterers
(4) Get an accurate count of the birds delivered
(5) During hot weather remove tarpaulins if truck should stop enroute Give the birds plenty of air Allow a space in the center of the load, between the tiers of coops
(6) Move pullets at night when the temperature is lower Trucks should *arrive at the flockowner's farm early in the morning*
(7) Some states have laws governing the production, sale, and moving of started pullets They may require a health certificate

Should You Grow Pullets or Purchase Them?

There probably is no direct answer to this question Many factors are involved Although the grower is entitled to a profit for his endeavors and a return on the money he has invested, a started pullet necessarily will usually cost more than the flockowner's expense of raising his own But the flockowner may decide that he could make more on his investment if the money were spent on his laying program rather than on his growing operation Furthermore, it may be worth more to the flockowner to be able to get good, uniform pullets when he needs them

GROWING COST MANAGEMENT

The only reason for growing a pullet is that she may produce eggs Thus, any pullet growing costs become a direct charge against egg production costs The greater the pullet expense, the greater the cost of producing eggs Reducing pullet production costs lowers egg costs

Example (1) If the Leghorn pullet growing cost is reduced by US$0.20, *the expense of producing a dozen eggs* will be lowered by US$0 01 per dozen, figuring on the basis of 20 dozen eggs laid per hen housed

Example (2) If the meat type breeder pullet growing cost is reduced by US$0 24, the expense of producing a dozen *hatching* eggs will be lowered by US$0 02 per dozen, figuring on the basis of 12 dozen hatching eggs laid per hen housed

Pullet Growing Costs

The costs of growing a pullet may be segregated according to the following

(1) day-old chicks (including transportation),

(2) feed;
(3) labor (including all benefits),
(4) medication and vaccines,
(5) consumable supplies (litter, disinfectants, light bulbs, etc.)
(6) vehicles,
(7) maintenance and repairs (items not capitalized),
(8) depreciation (or rentals, leases, contracts for growing houses, etc);
(9) other costs

In the case of integrated operations or pullet growout projects, the above classification will have to be altered to include such items as supervision, growout labor and equipment contract, bonuses, etc., but this will not alter the need for a tight control over costs if they are to be reduced to a minimum

Estimated Costs

When the poultryman owns his own house and equipment, and takes care of the birds, an estimate of the cost breakdown for Leghorn, medium-size commercial pullets, and meat-type, breeder replacement pullets is found in Table 14.6

TABLE 14 6

ESTIMATED COST TO PRODUCE A PULLET TO 20 WEEKS (140 DAYS) OF AGE HEN HOUSED BASIS
(In U S Dollars)

Cost Item	Commercial Leghorn Pullet	Commercial Medium size Pullet	Breeder, Meat type, Replacement Pullet(7)
Day old chick	$0 30	$0 32	$0 50
Feed	0 53(1)	0 58(2)	0 70(3)
Labor	0 21(4)	0 24(5)	0 30(6)
Medicines and vaccines (8)	0 10	0 10	0 15
Consumable supplies	0 02	0 03	0 04
Vehicles	0 02	0 03	0 04
Maintenance and repairs	0 01	0 02	0 03
Depreciation	0 08	0 10	0 12
Other	0 02	0 02	0 03
Mortality (9)	0 10	0 12	0 20
TOTAL	$1 39	$1 56	$2 11

(1) 15 lb (6 8 kg) @ $ 035 per lb ($ 077/kg)
(2) 16 5 lb (7 5 kg) @ $ 035 per lb ($ 077/kg)
(3) 20 lb (9 1 kg) @ $ 035 per lb ($ 077/kg)
(4) 7 minutes @ $ 03 per minute
(5) 8 minutes @ $ 03 per minute
(6) 10 minutes @ $ 03 per minute
(7) No males included
(8) Breeder birds require larger expense
(9) House 90% of those started

If contract growing is involved, the cost breakdown of a growing pullet is shown in Table 14.7, where it is assumed that the grower is paid a predetermined amount for the use of his buildings and his labor. Although the table shows the costs through the 21st week, most pullets are moved to their permanent laying quarters earlier than this, sometimes several weeks. But regardless of the moving date, growing costs accumulate until the birds are at least 21 weeks of age, and sometimes longer.

TABLE 14 7

ESTIMATED CONTRACT COST TO PRODUCE A PULLET TO 20 WEEKS (140 DAYS) OF AGE HEN HOUSED BASIS
(In U S Dollars)

Cost Item	*Commercial* Leghorn Pullet	Commercial *Medium size* Pullet	Breeder, Meat *type, Replacement* Pullet(4)
Day-old chick	$0 30	$0 32	$0 50
Feed	0 53(1)	0 58(2)	0 70(3)
Growout contract	0 29	0 35	0 39
Medicines and vaccines	0 10	0 10	0 15
Consumable supplies	0 01	0 02	0 03
Vehicles (supervisor)	0 03	0 04	0 05
Supervision records	0 05	0 07	0 09
Other	0 03	0 03	0 05
Mortality(5)	0 13	0 15	0 22
TOTAL	$1 47	$1 66	$2 18

(1) 15 lb (6 8 kg) @ $0 35 per lb ($ 077/kg)
(2) 16 5 lb (7 5 kg) @ $0 35 per lb ($ 077/kg)
(3) 20 lb (9 1 kg) @ 035 per lb ($ 077/kg)
(4) No males included
(5) House 90% of those started

Variations in Growing Costs

Although only three lines of birds are found in Tables 14 6 and 14 7, there are other types of chickens that will involve different estimated computations Furthermore, itemized costs will vary according to the region where the birds are grown feed price, labor cost, contract agreement, breeding or commercial flock, investment, chick cost, and many other factors will affect the total cost Each operation will need a different set of figures, but when similar tables are constructed under different conditions, estimated costs must be based on a good operation They need not be goals, but they should represent what could be accomplished under good management

Male Costs

When replacement breeding pullets are involved, either egg type or meat type, the cost to raise the accompanying males must be considered Although the procedure for handling these costs is probably not the best, male costs are usually added to the cost of raising the breeder pullets Thus, the pullet-growing cost under this system is not an accurate interpretation of actual pullet cost However, Tables 14 6 and 14 7 show the cost for meat type pullets only

Cash vs Accrual System of Bookkeeping

Most smaller poultrymen keep their books on the cash system, larger operators usually go to the accrual system, but not all In many instances the cash system of accounting has an advantage from a tax standpoint, but the procedure will never give a true picture of the cost of producing a pullet Costs must be broken down into their various components regardless of the type of bookkeeping system employed

Cash system of accounting Cash expenditures and cash income, along with a few other items, are used to determine cash costs, cash income, and cash

profit. Many important costs do not appear in the records, and there is no correlation between the time of the cash expenditure and the time of actual use. For instance, feed may be purchased at the end of one month, but not fed until the next month.

Accrual system of accounting: This system gives the producer an exact cost of his expenses, income, and profit. But it may have a disadvantage from a tax standpoint. However, some type of accrual bookkeeping should be employed even if the cash system is used. This is necessary to get a picture of the actual monthly cost and profit. *At times only an accrual record* will be necessary on the smaller poultry farm. Such a record should contain:

(1) cost of actual feed consumed by the birds;
(2) actual labor cost (family labor included);
(3) bird inventory (increase or decrease);
(4) consumable supplies actually used;
(5) depreciation cost (buildings and equipment);
(6) other actual costs.

Interest Expense

From a cost accounting standpoint, interest is not a *production expense.* In bookkeeping procedure it is broken out of production costs and placed in the General & Administrative account. This is necessary, because interest is highly variable. One flockowner could have borrowed a great amount of money resulting in a high interest charge; another might have no borrowed money, and no interest obligation.

Interest on investment: This is a rather fictitious expense figure, and means little. Such an investment figure, determined as the value of what the invested money would draw if placed on loan, is added as a direct cost of production. *No other business uses this procedure. Profit should not be* determined in this manner. Rather, it is better to determine the actual profit, then calculate the profit as a percent of the fixed assets (investment in land, buildings, and equipment), or as a percent of the total money invested.

Capitalizing Pullet Costs on Accrual System

When the *accrual system* of bookkeeping is used, it will be necessary to capitalize the cost involved with growing the pullets to be used for commercial egg production (or for pullet and cockerel costs when a breeder replacement flock is involved). As capitalized, pullet-growing costs are offset by inventory valuations; there is no profit or loss involved with the growing process. Once capitalized, however, the amount must be reduced during the period of egg production, usually by a procedure of charging an equal amount to each dozen of commercial eggs or hatching eggs produced.

Age to capitalize: If flocks are to be capitalized, there can be a great difference in the age of the birds when the accounting capitalization takes place. When it is early, such as at 18 weeks of age, the flock will not be fully grown, and remaining growing costs will be charged to the laying period, adding to the expense prior to sexual maturity when no egg income is

forthcoming If capitalization is delayed until after the birds are producing eggs, some "laying costs" get into growing costs When growing costs are capitalized at sexual maturity when egg production starts, book financial losses will occur for several weeks after capitalization because egg income will not be sufficient to offset the costs of maintaining the laying flock For this reason most people like to capitalize the commercial flock when it reaches about 50% hen day egg production This will be about one month after egg production begins Thus if a flock of commercial pullets were to lay its first eggs at 21 weeks of age, the flock would be considered a "growing flock" until it was 25 or 26 weeks of age At this time the income from eggs produced would offset the cost of maintaining the laying flock Of course the delay increases the "growing costs" and adds to the amortization cost per dozen eggs produced during the laying period The *amortization cost per dozen eggs* is the "pullet cost" at capitalization, less the salvage value at the end of the laying year, divided by the number of dozen eggs the bird will lay during her production cycle

Capitalizing started pullets Regardless of the age at which the started pullets are received on the laying farm, in most instances the pullets should not be capitalized until they are 24 to 25 weeks of age Costs involved at the laying farm prior to this age should be charged to "growing costs"

Reducing Growing Costs

Cost management involves the reduction of growing costs to their minimum without impairing the productivity of the birds during their first laying cycle. There are many avenues open to such a reduction

Reduced feed cost This is the largest of the growing cost items, thus it becomes one of the most vulnerable Excessive feed cost should be examined critically

(1) Is the feed the right feed?
(2) Are the protein and energy values correct?
(3) Is the ration being fed correctly?
(4) Is the feed priced right?
(5) Is there feed wastage?
(6) Should feed restriction be practiced?

Labor cost In most cases this is the second largest of the pullet-growing costs Labor efficiency has become an important item in this age of high labor rates If pullet-growing costs are to be reduced, the farm must be automated as much as possible, and there must be enough birds to keep the labor force busy Labor inefficiencies cannot be tolerated

Other cost items There are many other cost items Some are open to efficiency reductions, little can be done about others For example, cost of medicines, vaccines, consumable supplies, etc , must be kept under constant scrutiny, while little, if any, reduction can be made in depreciation, light and power rates, etc

Mortality as a cost item Although not a direct cost, mortality plays an important part in the cost of raising a pullet One should "house" at least 90% of the pullets started, except where selection pressure is necessary for breeding flocks The cost of keeping a bird until it dies must be charged

to those living, thus raising the growing cost of the live birds. Probably nothing is more costly than "excessive" mortality. Not only is there a bird loss, but the profit the birds would have produced is lost.

Quality of grown pullet important: The productivity in the laying house or cage is due in great part to the quality of the pullet at the time she reaches sexual maturity. Cost management involves quality management. No program of reducing growing costs should impair the quality of the mature bird.

Laying Management

This chapter deals with laying strains such as Leghorns, mini Leghorns, and medium size pullets kept for the production of commercial eggs Management of breeders is discussed in Chapter 16 Furthermore, littered floor operations only are considered here, cage management is to be found in Chapter 17

DEFINITIONS

"Laying Period"

The *laying period* or *laying cycle*, as some prefer to call it, is difficult to define There are many ways to describe the length of time involved But in this text it starts when the birds reach 5% egg production on a hen day basis and continues until the birds are sold at the end of a laying period of normal length, or are force molted

Production laying period different from bookkeeping laying period

Often laying birds are not capitalized on the books of the company until they are 25 or 26 weeks of age, when egg production has reached 50% or higher Thus, there is no similarity between the production period and the bookkeeping period Each should be considered a separate entity, and this distinction must not be confused

"Housing Time"

The term "housing time" or "housed" is also indefinite in poultry nomenclature Formerly, it meant the time when birds were placed in the laying house just before the onset of egg production But with modern methods of poultry production it is better that the term be synonymous with 5% hen day egg production Thus, the *number of pullets housed* is the number in the laying house when the birds reach 5% egg production on a hen-day basis

Age of Moving to Permanent Laying Quarters

Because of variations in growing management procedure, pullets are moved to permanent laying houses at ages between 14 and 21 weeks Therefore the laying quarters are used for "growing" for some period before the pullets reach 5% egg production However, another management change confuses the picture even more when laying rations replace growing rations just before the birds drop their first eggs Thus housing age, age to change to a laying ration, and start of laying period do not coincide Each must be treated independently

FACTORS AFFECTING LAYING HEN BEHAVIOR

Many things affect the hen's ability to produce eggs economically Necessarily, one must start with a good, well-developed pullet, for how she was grown will have a great effect on her productive performance during her laying period But once she begins to produce eggs, her ability to do her job well will depend on

(1) *Proper environment* House temperature, humidity, and airflow affect the number of eggs a bird will lay

(2) *Modern and adequate equipment:* The type of equipment influences egg production. Properly automated equipment will aid in the economical production of eggs.
(3) *Endocrine activity:* Light stimulates the activity of certain endocrine glands, and in turn egg production is increased. Close regulation of the number of hours of light given the birds each day is an important factor in maintaining maximum egg production. Natural daylight must be supplemented by artificial light during certain seasons of the year. See Chapter 18.
(4) *Balanced nutrition:* All laying pullets must be fed properly. The ration must be balanced to keep the flock nutritionally healthy and to maintain optimum body weight. Furthermore, the maximum number of eggs must be produced at the lowest possible feed cost.
(5) *Livability:* A large percentage of the pullets must live to the end of their laying cycle. Excessive mortality is usually associated with increased morbidity, causing flock egg production to drop below the normal rate.
(6) *Reproductive performance:* Not only should a flock produce a large number of eggs, but it must also produce large eggs that are of good quality.

TEMPERATURE AND LAYING PERFORMANCE

The details of adequate and proper housing are discussed in Chapter 11. Providing an optimum laying environment starts with a good house. It must be capable of protecting the birds from climatic variations encountered with normal day-to-day changes in temperature, for egg production falters when the pullets are subjected to temperatures above or below the optimum.

How Temperature Increases Affect the Bird

As the ambient temperature rises, the laying pullet undergoes many changes:

Rising temperatures increase

- water consumption;
- respiration rate;
- body temperature.

Rising temperatures decrease

- oxygen consumption;
- blood pressure;
- pulse rate;
- thyroid size and activity;
- blood calcium level;
- feed intake;
- bird weight;
- egg production;
- egg weight;
- eggshell quality;
- shell thickness;
- interior egg quality.

The Challenge of Hot Weather

At temperatures above 80° F (26 7° C) laying pullets begin to suffer, and the cost of producing market eggs increases At 100° F (37 8° C) things become serious Egg production drops drastically, and many birds may die from heat exhaustion The skilled manager is one who can cope with high outside temperatures by reducing the temperature inside the house Too often nothing is done, the manager just takes the heat as an "act of God," and offers no remedial measures

Handling the conventional house Even with the open sided house many programs can be used to reduce the house temperature and to make the laying pullets more comfortable

- Insulate the ceiling
- Increase ventilation
- Move the air faster by providing fans
- Lower the humidity
- Use foggers
- Sprinkle the roof—run sprinklers intermittently
- Wet the area outside and around the house
- Provide cool nests—open the backs
- Give cool, fresh water
- Increase the waterer space
- Give fresh feed during the morning and evening cool hours

Handling the environmentally controlled house The totally dark house that uses forced air for ventilation may present hot weather problems greater than those incurred with the conventional house Certainly the house should be well insulated to reduce the penetration of heat from the sun's rays Fans should operate at their maximum capacity Foggers should be used in the building Be cognizant of the fact that birds on slats are hotter than those on a floor, because the floor is quite cool compared with the air, and birds can "bury" themselves in the litter to get the coolness from the floor When they are on slats or wire, they are completely surrounded with hot air

There is no doubt that the solution to cooling the environmentally controlled house lies with the evaporator pad It is the best system known today, and is being installed in more and more laying houses See Chapter 11

Cold Weather Problems

Although cold weather must be compensated for, warming the poultry house much easier than cooling it All heat in the building is supplied by the birds, the amount of air moving through the house must be reduced to conserve heat Insulation, draft proof walls, curtains, and reduced fan speed have place in conserving heat, each being effective in controlled-environment houses

Moisture buildup As the amount of air flowing through the poultry house is reduced to conserve heat during cold weather, less moisture is moved out of the building Litter becomes damp or wet and creates a difficulty Although dry litter may be added and mixed with the wet to improve its consistency, such a program is too expensive to be carried out over a long period of time The manager's ability to regulate the movement of air to

remove most of the moisture from the house while conserving as much heat as possible provides the normal solution to the problem

House temperature below freezing When the outside temperature gets very low, it may become impossible for the birds to generate enough heat to keep the temperature inside the house above freezing Water in the waterers may freeze, pipes burst, and the combs and wattles of the birds may freeze Egg production suffers, and if the cold weather continues for some time the birds may undergo a partial molt When laying birds are to be kept in such a climate, better house construction is the only positive answer to the difficulty Although inside freezing results in bird disaster, the physical well being of the layers diminishes when the house temperature drops below 55° F (12 8° C) The optimum house temperature is between 65° and 75° F (18 3° to 23 9° C)

Reduced feed consumption As temperatures drop, the birds eat more feed in an endeavor to maintain their body temperature But in many instances layers are fed a restricted or controlled amount of feed each day If the feed requirement to maintain body temperature and egg production is greater than the feed given, the layers will reduce their production of eggs in order to use the feed for body heat rather than for eggs The good manager will make adjustments in the feed allocation when cold weather strikes

REQUIREMENTS FOR LAYERS

Unlike growing birds, the house and equipment requirements of layers remain constant They differ, however, with the size of the birds There are three size categories

(1) Mini-Leghorns
These are smaller than regular Leghorns so common for the production of eggs, their size being determined by a gene for dwarfism Although relatively new in commercial poultry production, they should be considered

(2) Leghorns (of normal size)

(3) Medium size
These are mainly for the production of commercial brown shelled eggs, and are larger than Leghorns

Floor Space

The larger the bird, the more floor space needed The type of floor also affects the space necessary Layers on slats or wire require less space than those on a littered floor Requirements are given in Table 15 1

Conditions affect floor space requirement The required floor spaces given in the table are average, and are generally recommended However, many things affect the space needed by each bird Crowding, *per se*, up to certain limits, does not seem to affect the general health of the birds However, it is difficult to reduce the floor space and maintain optimum conditions in the poultry house The temperature rises, and the litter becomes wetter Therefore, the bird density usually may be increased as long as environmental conditions in the house do not drop below optimum It

TABLE 15.1

FLOOR SPACE REQUIREMENTS FOR LAYERS(1)

Type of Floor	Mini Leghorns			Leghorns			Medium-size		
	Sq Ft	Sq M	Birds per Sq M	Sq Ft	Sq M	Birds per Sq M	Sq Ft	Sq M	Birds per Sq M
All litter	1.25	0.11	8.6	1.75	0.16	6.2	2.00	0.19	5.4
Slant and litter(2)	1.00	0.09	10.8	1.50	0.14	7.2	1.75	0.16	6.2
Wire and litter(3)	1.00	0.09	10.8	1.50	0.14	7.2	1.75	0.16	6.2
All-slat	0.66	0.06	16.3	1.00	0.09	10.8	1.25	0.11	8.6
All wire	0.66	0.06	16.3	1.00	0.09	10.8	1.25	0.11	8.6

(1) Floor space requirements must be a happy medium between that required for maximum egg production and that which produces wet litter and poor house ventilation.
(2) Approximately 40% litter, 60% slats.
(3) Approximately 40% litter, 60% wire.

must be remembered however, that as bird density increases, the productivity of the flock will decrease. The two factors must be considered when studying the most economical amount of floor space for each bird. Sometimes one can sacrifice some productivity in order to reduce the housing cost per bird.

Type of Floor

When it is to be covered with litter, the floor may be either dirt or concrete. Concrete certainly has its advantages and is to be recommended where the soil is not porous, sandy, or has good drainage. Concrete floors are easier to keep clean and maintain. There is less likelihood that disease organisms will be carried from one group of birds to the next when concrete is used and cleaned before a new group of birds is placed in the house.

Room Size

The present tendency is to house layers in larger groups than formerly. However, extremely large populations have disadvantages, and for best results the pens should be constructed so as to hold a maximum of 1,000 layers.

Equipment

Special equipment must be provided for laying pullets. Some of it is required to provide only for egg production.

Feeders. The feeders to be used should at least be the same type as those employed for growing birds, but the amount of feeder space necessary for each bird is greater. Keep the bottom of the feeder 1 in (2.5 cm) above the backs of the birds. *Remember* that about 30% more birds can eat from the same feeder space provided by a round pan as compared with that provided by a straight trough.

Waterers. Many types of waterers are in use in laying houses. Some are automatic, trough type. Some are circular. Others have running water. Pans, cups, and nipples are less common, but available. Keep the water level 1 in (2.5 cm) above the backs of the birds. Table 15.3 gives the waterer requirement for layers of different sizes during periods of hot weather. *Don't forget* that pullets will drink more water when temper

TABLE 15.2

FEEDER SPACE REQUIREMENTS FOR LAYERS

Item	Mini-Leghorns		Leghorns		Medium-size	
	In.	Cm	In.	Cm	In.	Cm
Trough space(1)	2.0	5.1	2.5	6.4	3.0	7.6
	Number of Pullets per Pan or Tube Feeder					
Pans(2)	25		20		16	
Tube feeders(3)	33		26		22	

(1) Space on *one* side of trough only.
(2) Approximately 12 in. (0.3 m) in diameter. Usually found on certain automatic feeders.
(3) A pan with a circumference of 50 in. (1.27 m) or a diameter of 16 in. (40.6 cm).

atures are high than when they are low, and the watering space should meet the maximum need.

Shell hoppers: Although most laying feeds contain ample calcium, on occasion supplementary feeding of oystershell or other form of calcium carbonate will be necessary. These may be fed in the automatic feeder, or mixed with the mash when the birds are hand-fed. If neither of these methods is suitable, shell hoppers may be used. These are usually hanging tube feeders. Supply one for every 250 pullets in the pen.

Grit hoppers: The recommendation for feeding insoluble grit to layers on littered floors is the same as that for supplying it to growing birds on littered floors. Grit should be fed when the feed is extremely coarse, when whole or cracked grains are being fed, or when the birds have access to litter and feathers. Provide one hanging tube feeder for each 250 birds in the pen. Feed 1 lb (454 gm) of grit per 100 birds per week. *Note* that this is a greater amount than fed caged layers.

Important: Insoluble grit as referred to here is not oystershell. Insoluble grit usually is granite, cracked to a specific size. Use the "adult bird" size for layers. Do not feed grit on a free-choice basis and do not feed that which is too small.

Nests: The *single-compartment* nest is preferred by most poultrymen keeping commercial layers. Provide one nest "hole" for each four pullets in

TABLE 15.3

WATERER SPACE REQUIREMENTS FOR LAYERS

Item	Mini-Leghorns		Leghorns		Medium-size	
	In.	Cm	In.	Cm	In.	Cm
Trough(1)	0.60	1.3	0.75	1.9	0.85	2.2
	Number of Pullets per Pan, Cup, or Drip Valve					
Pans(2)	65		55		47	
Automatic cups	18		14		12	
Drip valves	13		10		9	

(1) Space on *one* side of trough only.
(2) Pans approximately 10 in. (25.4 cm) in diameter.

order to have an ample number during the height of egg production Sufficient nests will aid in the prevention of floor eggs Hens will use nests of this type better if the nests are placed crosswise of the house As such nests usually are manufactured in tiers, place the floor of the lower tier 24 in (0 61 m) above the floor

If *community nests* are used, there should be one for every 35 hens Community nests are compartments about 2 × 8 ft (0 6 × 2 4 m) in size with a hole at each end through which the birds enter and leave The bottom of the community nest should be 24 in (0 6 m) above the floor

Another innovation is the *roll-away nest* It is similar to the single or community nest except that wire or other material is used in the bottom and sloped so that the eggs roll to a compartment at the back Two such nests may be placed back to back and a collecting belt used to move the eggs from the nests to a room at the end of the house When roll away nests are used in a house having a littered floor, the bottoms should be 24 in (0 6 m) above the floor When an all slat or all wire floor is used, there will be fewer "floor eggs" (laid on the slats or wire) if the nests are set on or very close to the floor

Automatic equipment Automatic equipment is becoming commonplace in in the laying house, feeders being one example Automatic feeders are usually run intermittently, a time clock is used to start and stop the feeder according to a required schedule Practically everyone uses some form of automation to replenish the water supply in the waterers Although automatic egg gathering is increasing in favor, this type of automation is still limited to a small percentage of laying houses

Many systems have been devised to keep the poultryman informed as to what is going on in the chicken house even though he is not there Alarm systems on motorized equipment may be installed to notify the caretaker at some remote point that something has failed to operate Closed circuit television units are being used to show how the birds are behaving in the laying house

Music in the chicken house Flightiness is common with certain lines and strains of laying birds Often it leads to hysteria Sudden, unusual sounds are a contributing factor In many instances musical sounds tend to calm the birds and reduce any piling or flightiness when the "unusual" occurs It is certainly far from uncommon to find radios playing loudly in the laying house Some poultrymen have recorded the noises made by "happy" hens in the course of laying or feeding, and play these recordings continuously throughout the day

Light timing devices Artificial light is a necessity in the laying house, and electricity to operate the bulbs must be turned on and off according to a predetermined schedule Automatic time clocks of a capacity ample to operate all the light bulbs are required

Egg storage Market eggs must be cooled as soon after laying as is practical In many instances a cooling room is constructed at one end of the poultry house off the feed and service room A refrigerated cooling device must be used to lower the temperature to 45° to 55°F (7 2° to 12 8°C), and keep it there automatically If eggs are to be shipped to a central grading station, eggs will be collected at the farm daily, or at least twice a week

TABLE 15.4

FLOCK SIZE AND EGG COOLER REQUIREMENTS
(Eggs cooled and cased twice daily)

Number of Layers	Number of 15-dozen Baskets or Piles of Flats to be Cooled at One Time	30-dozen Cases to be Stored. Eggs Picked up Twice Weekly	Minimum Size of Cooler Ft	Minimum Size of Cooler M	Btu of Cooling Required
5,000	10	44	6 × 8	1.8 × 2.4	4500
10,000	20	88	9 × 9	2.7 × 2.7	7500
20,000	40	176	10 × 14	3.1 × 4.3	12000
30,000	60	264	14 × 16	4.3 × 4.9	20000

Flock size and cooler requirements: The size of the cooler room and the cooling equipment may be correlated with the size of the laying flock. Recommendations are given in Table 15.4.

Bulk feed bins: Bulk feed bins should hold a week's supply of feed, plus about two days' reserve. Feed consumption over a seven-day period will vary according to the density of the feed used, the size of the birds involved, the environmental temperature, the feeding program, and other factors.

Scales for weighing feed: It is essential that a record of daily feed consumption be kept. This is difficult when bulk feed is fed unless scales are used to weigh accurately each day's supply. In some instances, a controlled feeding program will be used. In this, an allotted amount of feed is provided each day, and it becomes essential to weigh the feed. Several types of scales are available. Some are automatic; others, semiautomatic.

Catching equipment: The good poultry manager will keep a record of the average body weight of his laying hens. A sample weighing should be taken every four weeks during the laying cycle. To do the job quickly and efficiently, catching fences, hooks, and suitable scales will be needed.

Dead bird disposal container: Dead birds should be put in a can or some similar container as soon as they are picked up from the house. Be sure these containers have covers and may be cleaned and disinfected easily.

PREPARING FOR THE PULLETS

When birds are to be moved from a growing house to a laying house just prior to sexual maturity, the usual routine of cleaning the house and equipment as outlined in Chapter 13 must be made a part of the management program. Young pullets must be given a clean start. However, if they have been reared in the laying house, no cleaning will be necessary. The use of the old litter should be continued, and the daily sanitation methods followed.

Litter in Clean Houses

If the house has been void of birds for some time and has been cleaned, it will need new litter. Provide a litter that is common to the area, free of mold, dry, clean, and economical. Add about 3 in. during summer months; 4 in., during winter months.

Nest Preparation

Nests should be in the laying house, and open, about a week before the first eggs are laid This allows time for the pullets to get accustomed to them prior to egg production In this manner fewer floor eggs will be laid, and the first eggs will be cleaner Use nesting material that is clean and of a type that will prevent as much egg breakage as possible Close the nests at night, even before eggs are produced It is a bad management habit to allow pullets to remain in the nests overnight

Lighting the Layers

Many growing pullets will have been on a light-control program during the growing stage The hours of natural plus artificial light per day must be increased when the birds reach sexual maturity, but the method of procedure is at the discretion of the manager poultryman It must also be tied in with an increase in feed allocation at this time Both are discussed in Chapter 18 on lighting

Automatic Equipment

Be sure that all automatic equipment is in proper working condition When an environmentally controlled house is involved, the standby generator should be run and tested before receiving the birds, and thereafter once each week during the laying period Automatic waterers should be inspected and carefully observed Be sure the valves are working properly, and are not leaking If waterers are in a different location from that the birds are accustomed to, add pans of water for a few days Take the first reading on the water consumption gauge If the birds do not become accustomed to the feeder location, place pans of feed on the floor until they get acquainted with them in the new area

MOVING THE PULLETS

When pullets are moved to the permanent laying house just before egg production care should be taken The stress of moving should be kept to a minimum

The problems of moving may be reduced by using some of all of the following precautions

(1) *Handle the birds carefully* There is reason to believe that most of the stress of moving pullets just prior to egg production is in the handling Transporting is a less serious hazard. Handling alone will cause the pullets to lose 2 or 3% of their weight, and it creates a stress Catch the birds by both feet Do not pick them up by their wings Place them gently in the coops, and remove them with the same precaution

(2) *Do not move during hot part of the day* Pick a cool day to do the moving When the weather is extremely hot, transfer the pullets during the cool part of the day, or even better, at night

(3) *Tranquilizers* To prevent flightiness and stress when catching the birds, tranquilizers may be used to quiet them Several commercial products are on the market

(4) *Blue comb disease* The stress created by moving during hot weather often precipitates an outbreak of blue comb disease See Chapter 41 The birds become dehydrated, are listless, and the combs and wattles become dark, blue, and dried. Some of the broad-spectrum anti

biotics have merit in reducing the incidence of the disease caused by moving. One should be fed before and one after moving if blue comb may be a factor.

SELECTING THE PULLETS FOR LAYING

Regardless of whether the pullets are moved from growing to laying houses just prior to sexual maturity, or whether they remain in the same house, some selection should be made at this time to remove the inferior birds. It is uneconomical to house a pullet that shows indications that she will not produce eggs at a profit. If the birds are moved at this time, each bird should be individually handled. If they are not moved, cull the inferior ones by catching them with a hook. Cull the pullets that are:

runty;	blind;
crippled;	injured.
emaciated;	

Sorting Pullets by Size and Weight

If pullets were moved to their laying pens at some time during the growing period, they should not be moved from pen to pen at sexual maturity. But if they are moved from growing to laying quarters just prior to sexual maturity, and there are pens in the house, a sometimes common practice is to sort the birds according to size and sexual maturity. About three segregations are made, placing the more mature birds in one or more pens, the medium-maturing ones in other pens, and the late-maturing birds in still others. There seems to be no scientific evidence that this procedure is of value in increasing the egg production of the entire group, or for any single group when the birds are placed on littered floors. It has not proved of value when birds are similarly sorted and placed in cages; all but the very small produce as many eggs as those with other body weights.

THE "AVERAGE" BIRD

Unfortunately, practically all poultry management procedures are built around flock averages. Feed consumption is based on a bird of flock *average weight;* medication is similarly calculated; egg production figures are for the average bird. A very small percentage of the birds in the flock are of "average" weight. The remainder are either larger or smaller. These variations are normal even in the healthy flock because there is no strain of birds so uniform that there are no variations. But one does not realize the variability until he studies the tables for broilers as found in Chapter 20. Some maximum and minimum body weights are given in Table 15.5, when the average weight of the flock of pullets is known. These figures begin with a 1 lb average body weight which would be during the growing period. Although variations occur according to the strain of Leghorns involved, the figures given are quite typical.

Individual Administration

It is not possible, nor is it economical, to try to feed, medicate, or manage birds on an individual basis. Feeding chickens is on a group basis, unlike the feeding of large animals such as the cow where feed allocations are based on age, body

TABLE 15 5

AVERAGE MAXIMUM AND MINIMUM PULLET BODY WEIGHTS

Average Flock Body Weight for Leghorn Pullets		Approximate Extremes in Individual *Body Weight in a Healthy Flock*			
		Maximum		Minimum	
Lb	Kg	Lb	Kg	Lb	Kg
1	0 45	1 24	0 56	0 76	0 34
2	0 91	2 50	1 13	1 50	0 68
3	1 36	3 78	1 71	2 22	1 01
4	1 81	5 08	2 30	2 92	1 32

weight, and milk production of each individual Vaccinations and medications also have a similar application in large animals and human beings The best that can be done with a flock of chickens is to administer to the "average" bird Obviously those that are smaller than average will get more than an adequate amount, those that are larger, will receive less But the poultry manager must be ever cognizant that these variations occur, and wherever possible, he must make adjustments to compensate for them

FEEDING THE LAYERS

Although the details of nutrition and feeding are discussed in Chapters 25 through 36, several items have a specific place in this section

The Feed

Selecting the correct laying ration is important Although most poultrymen do not have access to feed formulas, there are many facts available to help them make decisions The form of feed (mash, crumbles, and pellets) must be taken into consideration Is phase feeding to be practiced? Is the daily feed allocation to be restricted or controlled during the laying period? What energy and protein content does the feed contain? All are important factors to be taken into consideration when he is planning the feeding program

Changing to a layer ration At about 21 weeks of age, the layers should be changed from a growing diet to a well fortified, properly balanced laying ration If the birds have been fed on a free-choice basis during their growing period, there is little problem in making the change, provided the *form* of feed is not altered at the same time, i e , changed from mash to pellets But if the pullets have been restricted in their growing feed intake, there may be difficulties in changing to the laying feed, particularly if the laying ration is to be self fed Sudden increases in feed consumption at the time laying has just begun will cause increases in body weight that are greater than normal This is to be discouraged Under such circumstances it is better to increase gradually the daily feedings of laying mash Increase the feed allocation at the rate of 1 lb (454 gm) per 100 pullets per day until they are on full feed

Lights important At about the time the change from the growing ration to the laying ration is made, the length of the light day must be increased The two procedures should coincide Do not allow an increase

in feed consumption at this time unless there is also an increase in the total hours of light (natural and artificial) the pullets receive. An increase of feed without an increase of light will cause the birds to put on too much weight. An increase of light without an increase of feed will not allow the pullet to gain enough weight during this period, and egg production will suffer. See Chapter 18.

Don't forget coccidiosis: When mature pullets reach the age of 21 to 22 weeks, they should have developed immunity to coccidiosis through a program of coccidiostat removal or by other means. But be careful. Laying feed does not usually contain a coccidiostat; if the growing feed contained this ingredient, and the laying feed doesn't, and the birds do not have full immunity, an outbreak of coccidiosis may occur in the laying quarters. At this age, the disease may prove disastrous; egg production will be delayed, and a less than normal number of eggs will be produced.

Feeding calcium carbonate: Growing feeds contain only enough calcium to support growth and bone development; they do not contain enough for maximum egg production. Consequently, there has to be more calcium in a laying ration than in a growing ration. However, a common practice has been to feed varying amounts of calcium carbonate (oystershell, etc.) near the end of the growing stage at about 16 to 18 weeks of age. The purpose has been to supplement the growing ration in order to build up a reserve of calcium in certain bones of the bird from which it can draw for the production of early eggs. This practice is not recommended. Wait until seven days prior to the start of egg production before increasing the calcium. *A slight delay is better than feeding too early.* As most laying rations have an adequate amount of calcium for egg production and body maintenance, and because the birds are changed to a laying ration about a week before egg production begins, the free-choice feeding of calcium is seldom necessary for more than two weeks.

Laying Feed Allocation and Body Weight

For maximum egg production during the laying cycle it is essential that the bird maintain a body weight that is congruous with her particular strain. These weights vary; some strains are naturally heavier than others, the difference being due to the genetic makeup of the line. Genetic breeders should be consulted about their recommendations for optimum weights during the egg-production period.

Because egg-type strains produce eggs so rapidly and use a great deal of their nutritional intake for egg production, in most instances body weight seldom gets too great. But factors other than egg production influence body weight, and on occasion it may be necessary to restrict the feed intake if body weight is excessive during the laying cycle. Some genetic breeders have schedules for feeding under such circumstances. See Chapter 35.

Weighing the daily feed allotment: Regardless of whether or not laying feed restriction is practiced, it is essential that daily feed consumption be known. This will require weighing the daily feed allocations, and keeping a record. At least once weekly, convert the daily feed consumption on the

basis of "feed consumed per 100 pullets per day" This is a standard index used throughout most of the poultry industry (Note Some countries use "ounces of feed consumed per bird per day")

Watch for a drop in feed consumption A precursor of flock trouble often is a drop in daily feed consumption For this reason a record of *daily* feed intake is much better than one for a longer period One can spot difficulties sooner

Feed wastage The feed cost of producing a dozen eggs is one indication of how well management is doing Everything that contributes to reduced costs must be routinely considered Feed wastage is in this category, and a careful observation of the hen house must be made regularly to prevent it from becoming a feed cost item

MANAGING THE LAYING FLOCK

The day-to-day management of the laying flock on a littered, slat, or part-slat (or part wire) floor taxes all the ability of most poultrymen It is during the period of egg production that profits are made or lost Maximum egg production is essential, and the value of daily flock care cannot be overemphasized

Litter Management

Although one should not be involved with a coccidiosis-control program during the laying period, the condition of the litter should be watched *Do not* allow it to become wet Too little moisture is better than too much for hen comfort But dustiness is to be avoided, chickens do not breathe well in such an atmosphere, and are more subject to respiratory ailments In the environmentally controlled house, correct the air intake and exhaust to maintain good house and litter conditions

Avoid Stresses

Difficulties arise when something happens to bring about a condition in the poultry house that is other than optimum The weather is continually variable, and proper ventilation of the building to offset outside climatic conditions cannot be overemphasized In many instances disease is a disastrous consequence of poor management Follow a recognized vaccination program and check blood titers to determine whether immunity has developed Be on the outlook for vices Cannibalism and hysteria can ruin a good group of pullets Take preventive measures before trouble begins See Chapters 14 and 41

Lighting Programs

To stimulate the production of eggs, light must be supplied *either* by natural daylight, by artificial light, or by both Full details for various lighting programs are given in Chapter 18 The details are too great for repetition here, but the following are routines of importance

(1) Clean the light bulbs regularly A good practice is to clean one third of the bulbs and reflectors each week
(2) Replace burned-out light bulbs daily
(3) Watch the length of the light day As daylight hours increase or decrease, the period of artificial lighting must be adjusted accordingly

(4) Do not decrease the total light day during the laying period. The light day must remain constant or increase as the production year progresses.
(5) Be sure the light intensity at floor level is correct. Either too little or too much light is to be avoided. Use a light meter if in doubt.

Nests

With conventional nests, provide one nest "hole" for every four pullets in the house. If this number is not provided at the peak of egg production, some pullets will be forced to lay on the floor, and may continue the habit when production is lower and not as many nests are needed.

Time of day eggs are laid: Egg production is not uniform throughout the hours that light is available. Although time of egg laying is not associated with the type of house, type of nest, density of the birds, or ambient temperature, the time of first light in the morning does produce an effect. Pullets will start laying eggs about one or two hours after the light is bright. The proportion of eggs laid during each hour thereafter is given below:

Hour after bright light begins	% daily total of eggs laid
1	Few
2, 3	40
4, 5	30
6, 7	20
8, 9	10
10, 11	Few

Close the nests at night: To prevent pullets from remaining on the nests overnight, any birds found on them at the end of the day should be removed, and the nests closed. Be sure to open them in the morning before the birds are ready to lay. Having nests empty when not needed at night will keep the litter cleaner, help prevent broodiness, and keep the eggs cleaner.

The egg pickup: Market eggs should be gathered at least three times a day during cool weather, four times during hot weather. Egg breakage will be reduced if there are few eggs in the nest at any period of the day. Do not leave eggs in the nest overnight. Pick up any remaining eggs when the nests are closed at the end of the day.

Eggs should be gathered on flats rather than in baskets or buckets. This avoids one handling, thus reducing breakage. When automatic egg gathering equipment is used, keep the pickup belt clean and remove eggs to flats as soon as they reach the collecting room. Always hold or pack eggs with the small end down.

Oiling Market Eggs

When eggs are to be washed several hours after gathering, they may be oiled at the time they are removed from the nest to facilitate the washing process. See Chapter 17.

Cooling Market Eggs

As soon as eggs are laid, their quality should be preserved by cooling Some means of refrigeration is necessary on most poultry farms Any laying house of size should have a refrigerated room where the temperature may be kept at optimum See Chapter 17

Broodiness

Broodiness, an inherited factor, was quite common to many strains of chickens a few years ago Today, however, the genetic factor has been eliminated from practically all Leghorn lines, but some broodiness may be evident in those birds producing brown shelled eggs Small cages, with a wire or slat floor, may be con structed in the poultry house When broody hens are removed from the nests and placed in these, the broody instinct will disappear in two or three days, and the pullets may be returned to the floor Supply feed and water to those birds in the broody coop When the birds are on all slat or all wire floors, broody coops will not be required

How to Prevent Floor Eggs

Eggs laid on the floor, rather than in the nests, are a costly expense Usually they are dirty, many are broken, and it is laborious to gather them Pullets must be trained to use the nests when they begin to lay Once they lay on the floor it becomes difficult to change their habit There are several helps in getting the birds in the nexts early

(1) Fence off the corners of the pen Corners are the most likely area for a floor "nest "
(2) Place the nests in a darker part of the house
(3) In houses with part slat floors, place the nest sections at right angles to the house One end may rest on the slats
(4) Use darkened nests Cover the upper part of the nest opening, and upper part of any back opening, to darken the nests But be careful during hot weather This procedure may cause excessive heat in the nests
(5) Open the nests and have nesting material in them a week before any eggs are produced Let the pullets get acquainted with them
(6) Have an adequate number of nests No pullet should be required to lay on the floor because she cannot find an empty nest
(7) Keep the nesting material clean and ample
(8) Sometimes roll away nests prove difficult, as the nest floor is usually wire, and the birds may refuse them at first Often covering the wire with coarse straw or a nest pad for the first week or two will induce the pullets to lay in the nests rather than on the floor

Culling

Individual unproductive and inferior pullets should be removed from the pens during the laying period Usually it is unwise to believe that these will be able to produce a profit Remove the birds with a hook about once a week Do not catch the entire group to remove the culls Such handling generally will reduce egg production in the entire flock

Sanitation and Medication

Maintain a strict sanitation program Keeping things clean is of vital importance to a profitable flock See Chapter 44 Medicate when necessary and as soon as possible Delays in treating the flock can be costly See Chapter 41 Keep flies under control

Records

Maintain adequate records What has gone on in the past should be a guide to future management procedures But do not keep too many records Record only data that will answer the major questions Too many figures are confusing It is better to have a few facts, and understand them well, than to become over whelmed with a maze of statistics

Compare your weekly production figures with known standards for the strain involved Just knowing the weekly egg production for the flock is not enough, it should be compared with a standard figure for a flock of the same age Only then will the poultryman know whether his flock is good, average, or poor See Chapter 23

ECONOMICS OF EGG PRODUCTION

There are many factors associated with the economics of egg production All involve cost management Mortality, feed cost, labor expense, overhead and management costs, egg production, egg quality, contract egg production, and many other factors are involved with the cost of producing a dozen eggs These are all discussed in Chapter 17 and should be studied thoroughly by the poultry man who is keeping his layers on the floor

Breeding Management

Keeping birds for the production of hatching eggs involves practices necessary for the production of commercial market eggs as well as those needed to get eggs that are fertile and that will hatch well Many of the management practices given in Chapter 15 (LAYING MANAGEMENT) will not be repeated in this section, therefore that chapter should be read first

Definition of Housing and Equipment Units

Most recommendations for floor space and equipment requirements are given on a *per bird* or *per pullet* basis As the two terms have somewhat ambiguous meanings, they must be accurately defined as used in this text

Per bird basis A *bird* refers to a male or a female

Example "Allow two square feet of floor space *per bird* in the laying house " This means that *each* male and *each* female is to get two square feet

Per pullet basis The term *pullet* is used when there are only pullets in the pen, or when there are cockerels and pullets in the pen In this book the unit recommendation for floor space and equipment need is given on the basis of *pullets only*, the requirement for the cockerels is not given, as *it* is incorporated in the pullet requirement

Example "Allow 3 sq ft of floor space per pullet in the breeding pen " If there were 500 pullets and 50 cockerels in the breeding pen, the floor space requirement would be 1500 sq ft (500 X 3), and this would allow enough floor space for both pullets and cockerels

PERMANENT BREEDER QUARTERS

The permanent breeder quarters are those in which the cockerels and pullets are kept during the laying period of the females, and during which time fertile eggs are produced

Biological Isolation

Most breeding birds are now subject to some type of disease free program Pullorum disease, Mycoplasma Gallisepticum, Mycoplasma Synoviae, and others are examples of such diseases, and the birds must be kept free of any pathogenic organisms specific to these diseases Isolation of the flock or flocks must be com *plete to prevent entrance of the diseases from the outside Use separate person-* nel, and they must shower and put on clean clothing before entering the premises For complete details see Chapters 13 and 41

Brood-grow lay System

With this system, the permanent breeding quarters also are used for brooding and growing Once the chicks are placed in a house, they never leave it There is no moving and this procedure eliminates a lot of the stress caused by transferring

birds from house to house, and reduces the incidence of "breaks" from MG and MS

Brood-grow System

Certain breeding birds, particularly the egg type strains, are often brooded and grown in the same house At 18 to 21 weeks of age they are transferred to the breeding quarters However, the stress of moving at this age is hazardous, as it occurs just prior to the onset of egg production—a critical period, when MG or MS breaks most often occur

Grow-lay System

This is a popular system on farms where there are brooding facilities capable of keeping the birds to 10 weeks of age in the brooding house The birds are moved to the permanent laying house at this age, when the stress of moving is less likely to cause an MG or MS "break"

The Breeder House

The floor of the breeder house is preferably of *concrete*, because it is more sanitary and easier to clean However, dirt floors are used in many locations where the soil is sandy, dry, and porous House style, ventilation, and automation are important to the type of building being used today More and more poultrymen incorporate environmental control in a light proof house because it is necessary to regulate the length of the light day to maintain satisfactory egg production

Floor space It is customary to give breeding birds more floor space than laying birds Because of the many types of floors and the variation in the size of the breeders, floor space requirements vary greatly as shown in Table 16 1

Floor type Although floor space requirements have been given for wire floors in Table 16 1, wire floors for meat type breeders have not been very

TABLE 16 1

FLOOR SPACE REQUIREMENTS PER BREEDER PULLET
(Males included)

	Type of Floor											
	All Litter			Slat (Wire) and Litter(1)			All-slat			All wire(2)		
Type of Breeder	Sq Ft	Sq M	Birds per Sq M	Sq Ft	Sq M	Birds per Sq M	Sq Ft	Sq M	Birds per Sq M	Sq Ft	Sq M	Birds per Sq M
Mini Leghorns	1 5	0 14	7 2	1 25	0 12	8 3	1 0	0 09	10 8	1 0	0 09	10 8
Leghorns (conventional)	2 0	0 19	5 4	1 75	0 16	6 2	1 25	0 12	8 3	1 25	0 12	8 3
Medium-size egg type	2 25	0 21	4 8	2 0	0 19	5 3	1 5	0 14	7 2	1 5	0 14	7 2
Mini meat type(3)	2.25	0 21	4 8	2.0	0 19	5 3	1 5	0 14	7 2	1 5	0 14	7 2
Meat type (conventional)	3 0	0 28	3 6	2.5	0 23	4 4	2.0	0 19	5 4	2 0	0 19	5 4

(1) Approximately 60% slats 40% litter
(2) Or plastic-type floors See next paragraph regarding precautions
(3) Mini meat type females mated with conventional-size males

satisfactory Sloping the wire is of some help The difficulty lies in the fact that birds do not mate well on wire, some fertility will be sacrificed This is true even for lighter breeds, but the reduction is not as great as for meat type birds Fertility will drop about 2 to 3% with Leghorns and 5 to 7% with meat type breeds When wire is used as the only floor material, plenty of supports should be used to keep the wire rigid and even Use a heavy-gauge wire A plastic material is now available to replace the wire It is said that better fertility results with plastic

Waterer space The requirements for waterer space are given in Table 16 2, and are on a *bird basis*, that is, the figures given are for each male and each female in the pen during periods of *maximum* water consumption

TABLE 16 2

WATERER SPACE REQUIREMENTS FOR BREEDER BIRDS

Type of Breeder	Space per Bird		Number of Birds per		
	Trough[1] In	Trough[1] Cm	Pan[2]	Automatic Cup	Drip Valve
Mini Leghorns	0 60	1 3	65	30	20
Leghorns (conventional)	0 75	1 9	55	25	17
Medium-size egg type	0 85	2 2	47	20	13
Mini meat type	0 85	2 2	47	20	13
Meat type (conventional)	1 00	2 5	40	15	10

(1) Space on *one* side of trough only
(2) Pans approximately ten inches (25 4 cm) in diameter

Nests Provide 1 nest for each 4 pullets in the breeding house Nests for meat type birds should be slightly larger than those for egg type

Light Adequate hours of light each day are a requisite for maximum hatching egg production as well as for commercial egg production A complete discussion on light is given in Chapter 18

WHAT SHOULD HAVE BEEN DONE

The ability to breed pullets to produce a large number of fertile eggs with high hatchability is determined in part by the quality of the males and females at the time egg production begins These things should have been done during the growing period (see previous chapters for details)

(1) *Proper vaccination* Vaccination procedures are different for breeding birds than for commercial laying birds Be sure the proper vaccinations have been made, and that blood titers have been conducted to determine immunity

(2) *Dubbing* Dubbing should have been done when the birds were one day old

(3) *Debeaking* It is advisable to debeak female breeders If they were not debeaked at a younger age, debeak them just prior to egg production Males, too, may have to have their beaks cut back slightly at this time

(4) *Males toe clipped.* Cockerels should have had their inside and back toes clipped at one day of age. If not, cut off the *toenails* of those same toes at this time.
(5) *Males dewattled:* Dewattling should have been done when the cockerels were 12 to 14 weeks of age. Do not dewattle just prior to the times the males are mated, as it reduces early fertility.
(6) *Six-to-eight-week selection pressure*· Meat-type lines usually require the removal of a certain percentage of the smaller males at 6 to 8 weeks of age, and sometimes a portion of the females. Generally, there is no such selection for egg-type lines at this age.
(7) *Mature selection pressure* Just prior to the onset of female egg production, the males and females of poor quality should be removed from the flock. It may also be necessary to remove some of the males at this time, to bring them to the desired ratio of males to females.
(8) *Sexing errors removed* Sexing errors should have been removed at about eight weeks of age. Make another final check at housing time.
(9) *Males with females* The males should have been with the females several weeks prior to the time they reach sexual maturity If it is necessary to place them together just before the pullets begin egg production, the males should be placed in the pullet pens late in the afternoon. This allows but a short period for fighting. By next morning the males should be quite docile The males may be given a tranquilizer. This will calm them for a period of about 24 hours.
(10) *Immunity to coccidiosis* Through some process, immunity to coccidiosis should have been established in the breeder flock This is especially important, susceptible birds should not be in the breeding pens when egg production starts
(11) *Freedom from internal parasites* If worms were present during the growing period, a good program of eradication should have been consummated, allowing the birds to start their breeding period worm-free.
(12) *MG-negative and MS-negative* Breeders, in most instances, should have been on a program of eradicating one or both of these diseases Make another blood test just prior to egg production.
(13) *Blood-test for pullorum disease* Just before or immediately after egg production begins, the cockerels and the pullets should be blood-tested if this method of pullorum control is to be a part of the management procedure
(14) *Raised on a special lighting program* Light control during the growing period is of great importance in preventing the onset of early sexual maturity in the pullets Improper lighting during this period cannot be corrected once the birds start to lay. See Chapter 18.
(15) *Correct mature body weight.* The feeding program during the growing period should have been one that produced a specified body weight at sexual maturity.

The above review of major management factors having to do with the growing period is given to reiterate the importance of getting certain jobs done during this time. *Remember* One can hurt, but cannot help, a 21-week-old bird.

IMPORTANCE OF BODY WEIGHT

Although it would be difficult to classify body weight as the most important criterion of egg size and egg production, it must be given top priority The manager who can control the body weight of his birds during the growing and egg production periods has accomplished one of the tricky phases of maintaining a flock of breeders

Mature Female Body Weight Important

The body weight of the *meat type pullet* is especially important, as meat-type lines are bred for fast body growth in the broiler house, and if the pullets are full fed during their growing period they will be much too heavy at sexual maturity to produce their maximum number of eggs during their laying cycle Furthermore, *the body weight of these birds also must be controlled during the period of egg production* There are no set rules, feed allocations must be made on the basis of maintaining a recommended body weight for the particular strain involved

In the past, egg type genetic breeders have suggested full feeding during the growing and laying periods This is possible because egg type birds do not put on excess weight, as do meat-type strains However, some feed restriction during the growing and laying periods is now being recommended for some strains of Leghorns Although body weight reductions are not as great as with meat type fowl, the feed allocations are materially smaller

The control of body weight of the male follows the pattern set forth for the female, for it is known that males live better and produce a higher percentage of fertility when their body weight is controlled and reduced One cannot afford to let breeding males get too heavy, either during the growing or the egg production period

Response to Correct Mature Body Weight of Breeder Females

Controlling growth weight of breeder females (and males) so that they reach sexual maturity with good body fleshing but without excess fat produces the following effects The response is greater with meat-type than with egg type birds

(1) Onset of egg production is delayed
(2) The first eggs are larger
(3) Egg production during the laying cycle is increased
(4) More hatching eggs are produced during the laying year mainly because of the larger egg size
(5) Laying house mortality is reduced
(6) The feed cost of growing a pullet to sexual maturity is usually lowered
(7) The feed cost of producing a dozen hatching eggs is reduced
(8) The fertility of the hatching eggs is increased
(9) The hatchability of the hatching eggs is improved

Weighing Birds During Laying Period

Using the procedure outlined for growing birds, the breeder females should be sample weighed once every four weeks during the laying cycle Weigh approximately 10% of the pullets in each pen, or from various areas of the house Weigh a sample of the males too

Body Weight Recommendations

Although each line of breeding birds will have a different weight, and each genetic breeder will have a weekly weight guide indicative of his particular line of birds, Tables 16 3, 16 4, and 16 5 probably represent weight averages for meat-

TABLE 16 3

AVERAGE FLOCK BODY WEIGHTS FOR LEGHORN BREEDERS(1)

Flock age		Female(2)		Male(3)	
Weeks	Days	Lb	Kg	Lb	Kg
7	43–49	1 25	0 57	1 60	0 73
8	50–56	1 48	0 67	1 80	0 82
9	57–63	1 70	0 77	1 99	0 90
10	64–70	1 91	0 87	2 16	0 98
11	71–77	2 11	0 96	2 32	1 05
12	78–84	2 30	1 04	2 47	1 12
13	85–91	2 48	1 12	2 61	1 18
14	92–98	2 64	1 20	2 74	1 24
15	99–105	2 78	1 26	2 86	1 30
16	106–112	2 90	1 32	2 98	1 35
17	113–119	3 00	1 36	3 09	1 40
18	120–126	3 10	1 41	3 20	1 45
19	127–133	3 19	1 45	3 31	1 50
20	134–140	3 28	1 49	3 41	1 55
21	141–147	3 37	1 53	3 51	1 59
22	148–154	3 45	1 56	3 60	1 63
23	155–161	3 53	1 60	3 69	1 67
24	162–168	3 60	1 63	3 78	1 71
25	169–175	3 67	1 66	3 86	1 75
30	204–210	3 92	1 78	4 20	1 91
40	274–280	4 02	1 83	4 63	2 10
50	344–350	4 11	1 86	4 78	2 17
60	414–420	4 17	1 89	4 87	2 21
70	484–490	4 23	1 92	4 96	2 25
80	554–560	4 29	1 95	5 04	2 29

(1) For the production of commercial pullets
(2) Medium-size strain of parent Leghorns
(3) Small-size strain of Leghorns Generally the male parent lines are smaller than the female parent lines

type, medium size, and egg type breeders during the growing and laying periods *Remember*, to achieve these weights some type of feed control usually will be necessary Full feeding would produce weights far in excess of those recommended, particularly with the meat type lines

RATIO OF MALES TO FEMALES

Too many males in the breeding pen reduce fertility, as do too few The correct ratio of males to females depends on the type and size of the birds involved, and is defined on the basis of the number of cockerels per 100 pullets Although the figures given in Table 16 6 are those usually recommended, a few extra males should be placed in the pens at the time the birds are mated to allow for some

TABLE 16 4

AVERAGE FLOCK BODY WEIGHTS FOR MEDIUM SIZE BREEDERS(1)

Flock Age		Female		Male(2)	
Weeks	Days	Lb	Kg	Lb	Kg
7	43-49	1 55	0 70	2 10	0 95
8	50-56	1 75	0 79	2 31	1 05
9	57-63	1 94	0 88	2 52	1 14
10	64-70	2 13	0 97	2 74	1 24
11	71-77	2 31	1 05	2 95	1 34
12	78-84	2 49	1 13	3 16	1 43
13	85-91	2 66	1 21	3 38	1 53
14	92-98	2 83	1 28	3 59	1 63
15	99-105	2 99	1 36	3 80	1 72
16	106-112	3 15	1 42	4 02	1 82
17	113-119	3 30	1 50	4 23	1 92
18	120-126	3 44	1 56	4 44	2 01
19	127-133	3 58	1 62	4 66	2 11
20	134-140	3 71	1 68	4 87	2.21
21	141 147	3 83	1 74	5 08	2 30
22	148-154	3 95	1 79	5 30	2.40
23	155-161	4 06	1 84	5 44	2 47
24	162 168	4 16	1 89	5 56	2.52
25	169-175	4 25	1 93	5 66	2.57
30	204-210	4 50	2 04	6 01	2 73
40	274-280	4 73	2 15	6 23	2 83
50	344-350	4 86	2 20	6 42	2 91
60	414-420	4 98	2 26	6 57	2.99
70	484-490	5 09	2 31	6 74	3 06
80	554-560	5 20	2 36	6 88	3 12

(1) Producing brown-shelled eggs.
(2) Not brothers of females Male lines are usually heavier than female lines

early culling and mortality from fighting There is no reason to believe that the type of floor influences the ratio, although birds mate better on litter than on wire or slats

PRACTICES NECESSARY DURING PRODUCTION PERIOD

General management practices for the breeding flock such as sanitation, parasite and insect control, and many daily routines are similar to those for growing birds or for those kept on litter for the production of commercial eggs Certain disease control blood tests, such as those for pullorum disease, MG, and MS, that are not needed for commercial layers will need to be made on breeders at about the time egg production begins

Avian Encephalomyelitis Test of First Hatching Eggs

Breeder birds should be vaccinated for AE during the growing period To determine whether the vaccination has produced the necessary immunity, several of the first fertile eggs laid by the flock should be submitted to a laboratory for an immunity test See Chapter 41

TABLE 16 5

AVERAGE FLOCK BODY WEIGHTS FOR MEAT TYPE BREEDERS[1]

Flock Age		Female		Male[2]	
Weeks	Days	Lb	Kg	Lb	Kg
7	43-49	2 57	1 17	2 98	1 35
8	50-56	2 75	1 25	3 27	1 48
9	57-63	2 94	1 33	3 57	1 62
10	64-70	3 13	1 42	3 86	1 75
11	71-77	3 32	1 51	4 15	1 88
12	78-84	3 51	1 59	4 45	2 02
13	85-91	3 70	1 68	4 75	2 15
14	92-98	3 89	1 76	5 05	2 29
15	99-105	4 08	1 85	5 34	2 42
16	106-112	4 27	1 94	5 63	2 55
17	113-119	4 46	2 02	5 93	2 69
18	120-126	4 65	2 11	6 22	2 82
19	127-133	4 84	2 20	6 52	2 96
20	134-140	5 03	2 28	6 81	3 09
21	141-147	5 22	2 37	7 11	3 22
22	148-154	5 40	2 45	7 40	3 36
23	155-161	5 60	2.54	7 70	3 49
24	162-168	5 78	2 62	8 00	3 63
25	169-175	5 94	2 69	8 20	3 72
30	204-210	6 38	2 89	8 72	3 96
40	274-280	6 68	3 03	9 00	4 08
50	344-350	6 98	3 17	9 28	4 21
60	414-420	7 29	3 31	9 57	4 34
70	484-490	7 45	3 38	9 85	4 47

(1) Broiler breeder parents
(2) Male weights are for male of male meat line they are greater than for brothers of a female in column for female

TABLE 16 6

RATIO OF MALES TO FEMALES IN BREEDING PENS

Male of Mating	Female of Mating	Mating Producers	Males per 100 Females
Mini Leghorn*	Leghorn (conventional)*	Commercial mini Leghorn pullet	8
Leghorn (conventional)	Leghorn (conventional)	Commercial Leghorn pullet (conventional)	8
Medium-size	Medium-size	Commercial medium-size pullet (brown eggs)	9
Meat type male line (conventional)	Mini meat type female line	Commercial broilers	6-7
Meat type male line (conventional)	Meat type female line (conventional)	Commercial broilers	11

*One method of making this mating

Other Tests During Laying Period

If the breeding flock is to have an MG free or an MS free status, it will be necessary to repeat the specific blood serum tests for these two diseases at intervals of four weeks during the period of hatching egg production See Chapter 41

Managing on Littered Floors

Clean and dry litter will be necessary if the breeders are kept on the floor Not only will this improve the general health of the birds, but will prevent the feet of the pullets from becoming dirty and carrying the dirt into the nests Hatching egg cleanliness is important in breeder operations

Prevent floor eggs Floor eggs usually are dirty, difficult to clean and sanitize, and a probable cause of "blowups" in the incubator A high percentage of them are broken, resulting in a direct loss There must be a low incidence of floor eggs if the breeding operation is to be practical and profitable The number of cracked eggs should never be over 2%

Have an adequate number of nests No hen should be forced to lay on the floor because there is no nesting space available Pullets seem to want to use the nests more if the nest sections are placed crosswise of the house

Managing on Slats and Litter

The poultryman keeping breeding birds, particularly those with meat type lines, has enjoyed the many benefits of the slat-and litter house in which slats cover approximately 60% of the area and litter 40% But there are some management problems

High incidence of floor eggs When the slats are placed at the front and back of the house with the littered area in the center, the central area is shaded by the slats, being covered with litter, this offers an ideal place for a "nest " A little added effort by the caretaker will be needed when the birds first start to lay, to train them to use the nests Do not put too much litter on the floor at first, add more later

Littered area hard to ventilate Protected on each side by the slats, the littered area will not be well ventilated on hot summer days Do not use solid supports to hold up the slats, but use wire to increase the air movement

Eggs laid on the slats Some birds will lay eggs on the slats in preference to the nests Individual hens seem to lay eggs continuously in one location or another, and it is difficult to discourage certain birds from "dropping" eggs on the slats Prevention is the best remedy, have the nests open and inviting before egg production begins Eggs laid on the slats are seldom salvaged, as most of them are broken or eaten

Managing on the All-slat Floor

Most poultrymen keeping meat type breeders have been discouraged with the all-slat house Usually fertility is lower, and most of the "floor eggs" laid on the slats are broken Leghorn and medium-size breeders seem to be better suited to slats, and many such birds are housed in this type of accommodation Many of these houses are now constructed using the deep pit principle, thus eliminating routine removal of the droppings

Flightiness on slats: Pullets—particularly Leghorns—tend to be more flighty on an all-slat floor. They may fly back-and-forth through the house if it is not separated by partitions. Light, flexible wire netting may be suspended at intervals crosswise of the house. The bottom edge should be loose and about 2 ft above the slats to allow room for the birds to walk under it.

Location of nests: The bottom of the nests should be closer to the floor than is the case with littered floors. This will prevent some of the "floor eggs," because the pullets can almost walk into the nests. However, placing the nests this low makes it more difficult to gather the eggs; there must be a happy medium. When eggs are picked up automatically by a belt, this low nest position is no problem.

Body weight on slats: There is some inclination for birds to get heavier on slats than on litter. They seem to exercise less, and the increased density of the birds makes it more difficult for them to move about. Both lead to increases in body weight. Thus, any feed control program to maintain body weight becomes more important when the birds are on slats.

Managing on Wire Floors

In general, wire floors present a breeder problem. Unless the wire is heavy, tight, and well supported so as not to be uneven, the birds will have difficulty in mating, and fertility will be reduced. There seems to be no difficulty in the bird's ability to move about on the wire; but if the house is composed of both wire and litter there is preference for the litter, which may cause an undue concentration of birds in the littered area.

Size of wire mesh: The mesh size of the wire should be 1 in. (2.54 cm) × 2 in. (5.1 cm). The short dimension should run lengthwise of the house. If possible these wires should be 12½-gauge; the crosswire should be 14-gauge. This will give added strength over the supports, and keep the wire more even.

Sloping wire floors: Welded wire fabric is the most practical for houses with sloping wire floors. With such fabric the wires running one way will all be on top of the wires running the other; the wires are not woven. Place the top wires so they run crosswise of the house; eggs will thus roll to the egg collecting area more easily.

There is some evidence to show that birds mate better when the wire is sloped, with little loss in Leghorn fertility, and slightly more in heavier breeds.

All-wire floor not for meat-type breeds: Although some experiments have shown that meat-type breeders do fairly well on the all-wire floor, field evidence indicates that this type of floor is not suitable for commercial production. Leg and foot problems in the males and the inability to mate well may reduce fertility to a nonprofitable level.

Wire-floored cages: Many Leghorn breeders are kept in large cages with wire floors. Most such cages are about four feet (1.2 m) deep and six feet (1.8 m) wide, holding about 25 pullets and two cockerels. The floor is sloped so that the eggs roll to a collection box at the rear, or there is a darkened compartment at the back in which the eggs are laid on the wire floor. The wire should be of a size similar to that used to cover larger

areas of a poultry house, well supported, and tight Although such cages are suitable for Leghorn and medium size breeders, they have not proved too good for meat type birds

MANAGING THE MALE FOR HIGH FERTILITY

Half the germ plasma of the newly hatched chick comes from the sire, half from the dam Therefore the few males in the breeding pen represent half the mating Their importance cannot be overestimated Not only do they produce their half of the genes that go to make up the new individual, but they are responsible for the sperm necessary for hatching egg fertility

Male Reproduction

The consistency of male chicken semen is related to the number of mature spermatozoa In the early part of the day semen is white and opaque, but as matings are consummated, it becomes clear and watery Each ejaculation varies from as low as 0 1 cc to as high as 1 0 cc The number of spermatozoa runs into the millions, yet there seems to be no correlation between the number and the percentage of fertile eggs produced Some males are sterile or partially sterile, either because of abnormal spermatozoa or insufficient semen production

Male chickens mate between 20 and 80 times a day, depending on competition, number of females available, social order, temperature, light, and many other factors Males may mate several times a day with the same hen They mate more frequently with pullets in the center of the female social order, rather than with the more precocious or timid individuals

It seems to make little difference when matings are made to produce the greatest fertility, but more mating usually occurs early in the day Fertile eggs will be produced for days after the males are removed from the flock, but if males are removed and new ones added the same day, fertile eggs produced after three days will be the result of matings by the new males See Chapter 4

Importance of Male Body Weight

It is just as important to grow a male of high quality as it is to grow a female of similar quality Too often the male is neglected Excessive body weight at maturity must be avoided, growing weight guides for the line involved must be maintained See Tables 16 3, 16 4, and 16 5 for suggestions for body weight of growing and breeding males

Cull the Males Often

During the breeding period, the males must be carefully watched Any inferior birds must be removed with a hook There is proof that males mate with certain females, and if a particular male becomes unable to mate, his matching females will not take another male until he is removed

Handle males carefully If it becomes necessary to handle males, catch them carefully by both legs or both legs and a wing Many males will be permanently injured if only one leg is used to catch them

Exercise the Males

Cockerels should be induced to exercise to prevent their legs from deteriorating Cockerel feeders create a great deal of exercise, the males must jump to get feed

from them. Feeding some grain in the afternoon in the litter induces scratching, a worthwhile exercise.

Equipment May Cripple Cockerels

Although the breeder pullets may jump over or move under most of the feeders and waterers in the poultry house, males will have difficulty because of their larger size Guards over the same equipment may be crippling devices. Place the feeders and waterers so that the males may move under or around them, rather than try to jump over.

The Timid Male

Males set up a social order, as do females. The more timid males must be adequately provided for. Be sure they are getting enough feed to maintain their recommended body weight. If underweight, it will be advisable to add cockerel feeders to the pen to increase the male feed consumption. Normally, when males have access to both conventional feeders and cockerel feeders, they will consume about half of their feed from each.

Enlarged Foot Pads

Some males will develop enlarged foot pads These often become inflamed, and the male will not mate. Wire and slat floors are instrumental in causing an increase in this difficulty If a male is seriously affected, he should be removed from the pen; such a bird seldom recovers In a test at Pennsylvania State College, fertility in meat-type breeders on a sloping wire floor was 9.2% less than in similar birds on a littered floor. It was 4% lower during the second 4-week period and nearly 17% lower during the seventh 4-week period. This reduction was partly due to the sore foot problem with the cockerels, which got progressively worse.

Replacing Males in a Pen

As birds progress throughout the laying cycle there is a natural reduction in fertility. A serious economic situation may be produced, hatches may become so poor as to be unprofitable. The problem is much greater with meat-type breeds than with egg-type. Some poultrymen replace the old males in a flock with a set of new and younger ones after about two-thirds of the egg production period is over. Although this certainly increases fertility, the procedure is costly, and not recommended. Generally the cost of raising a new set of males does not offset the cost of the reduced fertility over such a short period of time as the last one-third of the egg production period.

Occasionally however, it will be necessary to cull such a high percentage of the males in certain pens that there will not be enough left to maintain high fertility. Although not generally recommended, one may have to move males from pens where there is an excess to pens where there are too few. In most cases any added males will not be able to establish a worthwhile place in the male social order and a great deal of fighting will ensue. Many of the added males will be crippled. To prevent as much of the fighting as possible, add the males to the pen about one hour before dark.

Males Not Mating

When breeder birds are kept in a house with a slat and litter or a wire and litter floor, males will have a tendency to remain on the slats or wire, as a sort of

"roosting" place Since many of the pullets will prefer to do their mating on the litter rather than on the slats or wire, such pullets will not be mated because the males will not leave the slats Feeding a small amount of whole grain in the litter in the middle of the afternoon will prevent a great deal of this difficulty, as it will cause the males to get off the slats in search of feed Mating on the litter will follow

LIGHTING THE BREEDERS

Light not only stimulates the production of eggs, but also increases the quantity and quality of the semen in the males It is very important that a specified lighting schedule be maintained during the breeding phase In many instances, artificial light will be needed to supplement the hours of natural daylight Conventional houses require a program different from those used in houses that are light proof (environmentally controlled) Chapter 18 gives these recommendations

FEEDING THE BREEDERS

Although feeding is discussed in detail in later chapters, some nutritional factors are closely associated with management and are best detailed here

Type of Feed

The poultry manager must make a feed selection before the birds reach sexual maturity He has several choices

(1) *Form of feed* Most breeder feeds are available as mash, crumbles, or pellets Mash is the predominant recommendation, as it is not generally necessary to try to increase feed consumption of breeders by the use of crumbles, as in the case of broilers Breeders tend to overeat rather than undereat However, to prevent Salmonella, MG, MS, and other organisms from gaining entrance to the isolated farm through the feed, many poultrymen have changed to pellets, because the heat generated in the pelleting process destroys many such organisms As a further precaution, some primary breeders manufacture their own feed and pellets

(2) *Controlled feeding* If controlled feeding is to be practiced during the breeding period to maintain required body weights of the birds, special rations may be necessary As an example, feed formulas high in protein and low in energy do not lend themselves well to a controlled feeding program

When to start controlled feeding Controlling the feed intake to compensate for any variations in body weight is the important feature of this system of feeding When the birds are changed from the growing ration to the breeding ration just prior to the onset of egg production, daily feed allocations should be increased gradually until the birds are on full feed Continue giving the birds all they will eat until they are two weeks past their peak of egg production, then begin to control the daily feed allocation so as to produce the desired body weight See Chapter 36

(3) *Phase feeding* Although highly popular with those poultrymen producing commercial market eggs, phase feeding has not been widely utilized by those keeping breeders. But since the economies of hatching egg production are becoming more important, application of this nutritional concept during the breeding cycle is gaining. Special rations are needed, and the decision to adopt phase feeding must be made before the breeder feeds are first fed.

(4) *Calcium in the diet* Calcium carbonate in some form should be self-fed to breeder pullets beginning seven days prior to the start of egg production, as with laying pullets See Chapter 15. Do not feed before this time, as early feeding tends to depress egg production. One week after the breeders reach 5% egg production, eliminate the self-feeding of calcium carbonate; most of it should be incorporated in the mash formula at the correct percentage. The remainder should be fed as flaked oystershell.

(5) *Grit.* Insoluble granite grit should be fed to breeders when the feed is extremely coarse, when whole or cracked grains are being fed, or when the birds have access to litter and feathers. Provide 1 hanging tube feeder for each 250 birds in the pen. Feed 1 lb (454 gm) of grit per 100 birds per week. Use the "adult" size of grit, and do not feed free-choice

HATCHING EGG PRODUCTION

The only reason for keeping breeding birds is to produce an abundant number of hatching eggs that will produce a high percentage of quality chicks Furthermore, *the hatching eggs must be produced as economically as possible without impairing chick quality.* A good egg usually means a good chick.

Hatching Egg Size

To prevent meat-type breeders from getting fat at the time sexual maturity is reached, some form of feed restriction during the growing period must be followed. In some cases, feed restriction during growing is used with egg-type birds Not only does this reduce body weight, but it delays onset of egg production. Controlled lighting programs produce a similar and supplementary reaction.

Egg size determined by chronological age of pullets Birds of a similar genetic makeup that are 26 weeks of age, for instance, lay eggs of a certain size regardless of when they started egg production. The same would be true at any other laying house age. Thus, holding the pullets out of production does not cause them to lay larger eggs; rather, the eggs are larger because the birds are older.

Minimum egg weight for hatching purposes Hatcheries usually set up minimum weights for the hatching eggs that they will incubate. The weight may be different for various lines and breeds. In some cases a lower weight is allowable during the first few weeks of egg production than is allowed later. Regardless of this, large first eggs are essential so that the poultryman can sell or deliver as many hatching eggs as possible over the life of the breeding flock. But it costs more to produce a pullet when she is kept out of egg production during a longer "growing" period. Thus

there must be a most economical age for the production of first eggs An analysis is given later in this Chapter

When to start saving hatching eggs There is evidence to show that chicks hatched from the eggs laid by a pullet during her first two weeks of egg production do not live well But after that, eggs may be used for incubation as soon as they are large enough The minimum size is determined by the needs of the hatchery using the eggs and by the size of the bird laying the eggs Although the minimum egg weight is variable, the following table will give some indication

Line of Parent Breeders	Minimum Egg Weight: First 12 Weeks of Egg Production (Oz/doz)	(Gm/ea)	After 12 Weeks of Egg Production (Oz/doz)	(Gm/ea)
Leghorn	22	52 0	23	54 3
Medium-size	23	54 3	23	54 3
Meat-type	21	49 6	22	52 0

In the above table it may be noticed that minimum egg weight suggestions are sometimes smaller during the first 12 weeks of egg production This is the result of two lines of reasoning

(1) Those hatcheries producing broiler chicks from meat type breeders can get more hatching eggs from first egg production Broiler weight shows little correlation with egg size at this time, but there is a greater correlation later in the production period

(2) Eggs produced at the start of lay are smaller than those laid later Because the same birds are laying them, the first hatching eggs have a genetic potential identical with those produced later Thus from a genetic standpoint, smaller hatching eggs may be used during the first 12 weeks of *total* egg production than may be used later Following the minimum size requirements regardless of the length of time the bird is in egg production will, of course, eliminate the smaller eggs through the entire production period

Shell Quality

Shell quality is associated with hatchability The longer a bird produces eggs, the poorer the shell quality Season of the year, strain, temperature, diet, and various other factors also affect the texture Although the quality of the eggshell remains quite acceptable for a 12 month laying period with egg type breeds, shell quality of eggs produced by meat lines begins to deteriorate rapidly after eight or nine months of lay During the second year of egg production (after force molting), shell quality deteriorates much more rapidly than during the first cycle, regardless of the breed

Interior Egg Quality

Although several of the factors causing fluctuations in the interior quality of eggs also produce variations in hatchability, the important factor is a condition known as tremulous air cells See Chapter 7 Some eggs are laid with loose air

cells; many more loose air cells are produced during the course of handling the hatching eggs before they are placed in the incubator. Handle eggs carefully, and prevent as much jarring as possible, to prevent the loosening of the air cells. Such eggs hatch poorly; many do not hatch at all.

Preventing Cracked Eggs

It is surprising how many hatching eggs are cracked during the process of laying and getting them to the incubator. A large proportion of the cracking is man-made; practically no eggs are laid with cracked shells. The desire of the caretaker to handle more birds, automation, improper holding containers, too many transfers, and inexperienced poultrymen contribute to the high incidence of breakage. As cracked eggs seldom hatch, and hatching eggs are expensive to produce, the economic loss is high on many farms. Sometimes 5% or more of the eggs laid are cracked between the nest and the incubator. Two percent is a tolerable maximum; 1% is an economic goal.

Clean Egg Production

When hatching eggs are gathered from the nest, they should be clean. Debris on the shells is unsanitary and difficult to remove.

Cleaning hatching eggs: Hatching eggs should be cleaned in the poultry house before they are fumigated. *Do not* wash them in the poultry house. Rather, sand or buff them in a dry state. It is not recommended that hatching eggs be washed at any time.

Warning: Do not oil hatching eggs. Oiling reduces hatchability.

Gather hatching eggs often: Hatching eggs should be gathered from the nests at least four times a day. In addition to these four collections, any eggs in the nests when the nests are closed at night should be picked up. Do not leave the eggs in the nest overnight.

Fumigating Hatching Eggs

Hatching eggs should be sanitized as soon as possible after they are gathered. Fumigation with formaldehyde gas is the most accepted practice. Eggs should be fumigated in a cabinet in the poultry house unless they can be delivered to a central location quickly and fumigated as soon as they arrive.

Remove Cull Eggs in the Poultry House

In many instances, hatching eggs are not graded for size in the hatchery. This is particularly true of those used to produce commercial broiler chicks. However, double-yolk, cracked, excessively dirty, ridged, and thin-shelled eggs should be sorted out at the time the eggs are gathered. Place them in a separate container or on separate egg flats. The remaining eggs may be easily handled in the hatchery with pneumatic pickup machines.

VACCINATING AND MEDICATING

Although pullets kept for the production of commercial market eggs are seldom vaccinated during their laying cycle, the program is different with breeding birds. In this case the production of parental immunity in the chicks is of utmost importance for uniformity of vaccination. To produce a constant degree of parental

immunity it will be necessary to revaccinate the breeder females for Newcastle disease and bronchitis at intervals of 12 weeks during the laying period See Chapters 41 and 43

BREEDER FLOCK COST MANAGEMENT

Probably no phase of poultry production is as dependent on cost management as the period when the breeder flock is producing hatching eggs The age at which the pullets lay their first eggs, egg size, length of time the birds are kept in egg production, in-season and out-of-season flock variations, and usage of hatching eggs—all have their effect on production cost and profit Undoubtedly these factors are of more importance to the flockowner keeping meat type breeders than to one keeping egg type breeders The inability of the meat type breeder to produce a large number of eggs, the large amount of feed consumed because of its heavy weight, the relatively short egg production period, and the high salvage value of the bird at the end of its laying year materially affect the economies of hatching egg production The egg type breeder is kept in egg production for a longer period than the meat type, it is not as greatly affected by climatic changes, it produces more eggs, feed consumption is lower as the result of a smaller size, and the salvage value is very small

Whether hatching eggs are being produced by an independent poultryman or by a contract producer does not influence the need for cost management of the breeder flock There must always be a consistent endeavor to keep costs as low as possible The effects of several of these factors are shown in the following sections

HATCHING EGG PRODUCTION COST

The cost of producing a dozen hatching eggs is a highly flexible figure Differences occur in flocks on the same farm even though the management procedure for each group is nearly identical One of the causes of the difference is the variability in the period of the year in which the breeder replacement chicks were started in the brooder, which in turn, alters the seasons in which eggs are to be produced The differences are shown in Table 16 7 for chicks hatched during the four seasons

Explanation of Table 16 7

Undoubtedly the figures in Table 16 7 are subject to many adjustments, as so many factors cause differences Line and breed of birds, length of laying period, lighting program, feed restriction, size of hatching eggs, etc , will change the data collected from field results It is almost impossible to secure evidence of this sort from controlled experiments, too many factors are involved Some explanations of the items are as follows

Age at 5% hen-day egg production This is an average age for birds kept in conventional, open-sided houses with a control of feed intake and a necessary lighting procedure during the growing period

Age at first hatching eggs This age would depend on the minimum size requirement of the first hatching eggs But the difference between age at first eggs and age at first hatching eggs would be similar, since it is based

TABLE 16.7

VARIATIONS IN BIRD BEHAVIOR ACCORDING TO SEASON CHICKS ARE HATCHED
(For conventional, open-sided houses)

	Leghorn Breeders(1)				Meat-type Breeders(2)			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
	Month in Northern Hemisphere(3)				Month in Northern Hemisphere(3)			
	F-M-A	M-J-J	A-S-O	N-D-J	F-M-A	M-J-J	A-S-O	N-D-J
Age at 5% hen-day egg production (wk)	22	22	22	21	23	24	23	22
Age at first hatching eggs (wk)	25	25	25	25	26	26	26	26
Length of egg production period (wk)	51	52	51	49	39	41	38	36
Number of hatching eggs produced	193	194	190	182	136	144	130	122
Hatching eggs as % of total eggs laid	87	87	86	84	94	95	93	90
Average egg weight (oz/doz)	23.7	23.8	23.6	23.3	25.3	25.4	25.2	24.9
Average egg weight (gm/each)	*56.0*	*56.2*	*55.8*	*55.1*	*59.8*	*60.0*	*59.5*	*58.8*
Feed per dozen eggs (males incl.) (lb)	4.21	4.20	4.22	4.26	7.32	7.31	7.34	7.44
Feed per dozen eggs (males incl.) (kg)	*1.91*	*1.91*	*1.91*	*1.93*	*3.32*	*3.32*	*3.33*	*3.37*

(1) 52 weeks of lay, all hatching months
(2) 41 weeks of lay for M-J-J hatch 39 weeks for F-M-A and A-S-O hatch, 37 weeks for N-D-J hatch
(3) Months must be reversed in Southern Hemisphere

on the relationship between egg size and the chronological age of the pullet.

Length of egg production period Out-of-season flocks cannot be kept in profitable hatching egg production for as long a period as in-season flocks. Although the difference is slight for egg-type strains, it is considerable in the case of meat-type lines.

Pullet Growing Costs

One of the important costs incurred in the production of hatching eggs is that of raising the sexually mature pullet plus the matching cockerel. This cost must be amortized over the egg production period on the basis of a constant value per dozen hatching eggs. Thus, any reduction in the growing cost will reduce the expense of producing a dozen eggs.

In Chapter 14, Table 14.6, the cost of raising a pullet to 20 weeks of age is given. These figures may be used as the base from which to arrive at the cost of producing a breeder-type female with the male growing costs included. These costs are shown in Table 16.8 for periods through 20 weeks of age and through 23 weeks of age; the latter is of importance when the growing costs are capitalized after the birds reach sexual maturity.

Cost of Producing a Dozen Hatching Eggs

Estimated costs of producing a dozen hatching eggs from Leghorn, medium-size, and meat-type breeder replacement females, with male costs included, are

TABLE 16 8

COST TO RAISE A MATURE PULLET (MALE INCLUDED)
(In U S dollars)

	Leghorn Pullet		Medium-size Pullet		Meat type Pullet	
	Cost through 20 Wk	Cost through 23 Wk	Cost through 20 Wk	Cost through 23 Wk	Cost through 20 Wk	Cost through 23 Wk
Base pullet cost to 20 wk of age (See Table 14 6)	$1 39	$1 39	$1 56	$1 56	$2 11	$2 11
Proportionate male cost to 20 wk of age	0 16	0 16	0 24	0 24	0 32	0 32
Bloodtesting, culling, and other costs at 20 wk of age (male incl)	0 24	0 24	0 26	0 26	0 33	0 33
Cost to keep pullet from 20 through 23 wk of age (male included)*	___	0 38	___	0 46	___	0 57
Total cost per pullet (male included)	$1 79	$2.17	$2.06	$2 52	$2 76	$3 33

*Value of eggs laid prior to 24 weeks credited to "growing" costs

given in Table 16 9 Naturally these costs will vary according to the price and quality of the feed, number of hatching eggs produced, pullet growing cost, mortality, and many other factors

BEST AGE FOR FIRST EGGS FROM MEAT-TYPE BROILER BREEDERS*

By careful manipulation of the length of the light day and feed intake, meat-type pullets may be brought into egg production at any reasonable age from 20 to 30 weeks But it costs more to raise a pullet to 28 to 30 weeks of age than to

TABLE 16 9

COST OF PRODUCING A DOZEN HATCHING EGGS
(In U S dollars)

Cost Item	Leghorn(1)		Medium-size(2)		Meat type(3)	
	Per Pullet	Per Dozen Hatching Eggs(4)	Per Pullet	Per Dozen Hatching Eggs(5)	Per Pullet	Per Dozen Hatching Eggs(6)
Pullet growing cost (including male)	$2.17	$0 155	$2.52	$0 158	$3 33	$0 278
Breeder feed cost(10)	3 08(7)	0 220	3 60(8)	0 225	3 68(9)	0 307
Labor	0 57	0 041	0 63	0 039	0 69	0 058
Other costs	1 07	0 076	1 27	0 080	0 67	0 058
Total cost	$6 89	$0 492	$8 02	$0 502	$8 37	$0 701

(1) 52 weeks of lay
(2) 52 weeks of lay
(3) 41 weeks of lay
(4) 14 dozen hatching eggs
(5) 16 dozen hatching eggs.
(6) 12 dozen hatching eggs
(7) 77 lb (35 kg) @ $0.04/lb ($0.088/kg)
(8) 90 lb (40 8 kg) @ $0 04/lb ($0 088/kg)
(9) 92 lb (42 kg) @ $0 04/lb ($0.088/kg)
(10) Male feed included.

*From an article by the author, *POULTRY MEAT*, May, 1970

20 to 22 weeks. The question is: Will the increased number of hatching eggs from a pullet kept out of egg production for 28 to 30 weeks compensate for the additional cost of keeping the growing pullet for that length of time?

The main object of delaying egg production of meat-type breeders is so that the first eggs will be larger; the bird produces more eggs of hatching size over her period of egg production.

Table 16.10 shows the costs involved in raising a pullet to various ages between 20 and 30 weeks, by weeks. The figures include male costs and consider the differences in mortality, feed consumption, labor, and other costs.

TABLE 16.10

MEAT-TYPE PULLET GROWING COSTS THROUGH VARIOUS WEEKS OF AGE (Male Included)
(In U.S. dollars)

Week of Age	Cost per Live Pullet				
	Chick	Feed	Labor	Other	Total
20	$0.72	$0.90	$0.55	$0.36	$2.53
21	0.72	0.97	0.57	0.39	2.65
22	0.72	1.03	0.59	0.41	2.75
23	0.73	1.09	0.60	0.44	2.86
24	0.73	1.16	0.62	0.47	2.98
25	0.73	1.23	0.64	0.49	3.09
26	0.73	1.30	0.65	0.52	3.20
27	0.73	1.37	0.67	0.55	3.32
28	0.74	1.44	0.68	0.58	3.44
29	0.74	1.52	0.70	0.61	3.57
30	0.74	1.60	0.71	0.65	3.70

Table 16.10 shows that the total cost of growing a pullet (male included) through 20 weeks of age is $2.53; through 30 weeks, $3.70, a tremendous difference.

Laying House Costs

In these computations the females are kept in egg production for nine months (38.7 weeks), including the week they attain 5% production; this time is about average under commercial conditions. The minimum hatching egg size is 22 oz per dozen (52 gm each), and no hatching eggs are saved until 10% of all eggs laid are hatching egg size.

Total cost to grow the pullet plus the cost involved in the breeding house is summarized in Table 16.11.

Cost Per Dozen Hatchings Eggs

Table 16.11 shows that both early egg production and a delay in the start of egg production mean an increase in the cost of producing a dozen hatching eggs. Lower egg production and small eggs increase the cost when production begins early, but if egg production is delayed too long the additional number of hatching eggs does not compensate for the additional cost of keeping the pullet out of production. Compared with the 24th week, it costs 11% more to produce a dozen

TABLE 16 8

COST TO RAISE A MATURE PULLET (MALE INCLUDED)
(In U S dollars)

	Leghorn Pullet		Medium-size Pullet		Meat type Pullet	
	Cost through 20 Wk	Cost through 23 Wk	Cost through 20 Wk	Cost through 23 Wk	Cost through 20 Wk	Cost through 23 Wk
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Proportionate male cost to 20 wk of age	0 16	0 16	0 24	0 24	0 32	0 32
Bloodtesting, culling, and other costs at 20 wk of age (male incl)	0 24	0 24	0 26	0 26	0 33	0 33
Cost to keep pullet from 20 through 23 wk of age (male included)*	—	0 38	—	0 46	—	0 57
Total cost per pullet (male included)	$1 79	$2.17	$2.06	$2.52	$2 76	$3 33

*Value of eggs laid prior to 24 weeks credited to "growing" costs

given in Table 16 9 Naturally these costs will vary according to the price and quality of the feed, number of hatching eggs produced, pullet growing cost, mortality, and many other factors

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(In U S dollars)

	Leghorn(1)		Medium-size(2)		Meat type(3)	
Cost Item	Per Pullet	Per Dozen Hatching Eggs(4)	Per Pullet	Per Dozen Hatching Eggs(5)	Per Pullet	Per Dozen Hatching Eggs(6)
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Labor	0 57	0 041	0 63	0 039	0 69	0 058
Other costs	1 07	0 076	1 27	0 080	0 67	0 058
Total cost	$6 89	$0 492	$8 02	$0 502	$8 37	$0 701

(1) 52 weeks of lay
(2) 52 weeks of lay
(3) 41 weeks of lay
(4) 14 dozen hatching eggs.
(5) 16 dozen hatching eggs
(6) 12 dozen hatching eggs.
(7) 77 lb (35 kg) @ $0.04/lb ($0.088/kg)
(8) 90 lb (40 8 kg) @ $0.04/lb ($0.088/kg)
(9) 92 lb (42 kg) @ $0.04/lb ($0.088/kg)
(10) Male feed included.

*From an article by the author, *POULTRY MEAT*, May, 1970

20 to 22 weeks. The question is: Will the increased number of hatching eggs from a pullet kept out of egg production for 28 to 30 weeks compensate for the additional cost of keeping the growing pullet for that length of time?

The main object of delaying egg production of meat-type breeders is so that the first eggs will be larger; the bird produces more eggs of hatching size over her period of egg production.

Table 16.10 shows the costs involved in raising a pullet to various ages between 20 and 30 weeks, by weeks. The figures include male costs and consider the differences in mortality, feed consumption, labor, and other costs.

TABLE 1610

MEAT-TYPE PULLET GROWING COSTS THROUGH VARIOUS WEEKS OF AGE (Male Included)
(In U.S. dollars)

Week of Age	Cost per Live Pullet				
	Chick	Feed	Labor	Other	Total
20	$0.72	$0.90	$0.55	$0.36	$2.53
21	0.72	0.97	0.57	0.39	2.65
22	0.72	1.03	0.59	0.41	2.75
23	0.73	1.09	0.60	0.44	2.86
24	0.73	1.16	0.62	0.47	2.98
25	0.73	1.23	0.64	0.49	3.09
26	0.73	1.30	0.65	0.52	3.20
27	0.73	1.37	0.67	0.55	3.32
28	0.74	1.44	0.68	0.58	3.44
29	0.74	1.52	0.70	0.61	3.57
30	0.74	1.60	0.71	0.65	3.70

Table 16.10 shows that the total cost of growing a pullet (male included) through 20 weeks of age is $2.53; through 30 weeks, $3.70, a tremendous difference.

Laying House Costs

In these computations the females are kept in egg production for nine months (38.7 weeks), including the week they attain 5% production; this time is about average under commercial conditions. The minimum hatching egg size is 22 oz per dozen (52 gm each), and no hatching eggs are saved until 10% of all eggs laid are hatching egg size.

Total cost to grow the pullet plus the cost involved in the breeding house is summarized in Table 16.11.

Cost Per Dozen Hatchings Eggs

Table 16.11 shows that both early egg production and a delay in the start of egg production mean an increase in the cost of producing a dozen hatching eggs. Lower egg production and small eggs increase the cost when production begins early, but if egg production is delayed too long the additional number of hatching eggs does not compensate for the additional cost of keeping the pullet out of production. Compared with the 24th week, it costs 11% more to produce a dozen

TABLE 16 11

PULLET COSTS AND COSTS OF PRODUCING ONE DOZEN MEAT TYPE HATCHING EGGS
(In U S dollars)

Age When 5% Egg Production Attained	Pullet(1) Cost	Net Laying House Cost(2)	Total Cost per Pullet	Total Net Cost per Dozen Hatching Eggs
20	$2 53	$4 87	$7 40	$0 654
21	2 65	4 93	7 58	0 628
22	2 75	4 99	7 74	0 606
23	2 86	5 05	7 91	0 593
24	2 98	5 11	8 09	0 589
25	3 09	5 15	8 24	0 591
26	3 20	5 18	8 38	0 594
27	3 32	5 21	8 53	0 600
28	3 44	5 23	8 67	0 606
29	3 57	5 24	8 81	0 613
30	3 70	5 26	8 96	0 623

(1) Males included
(2) Males included Value of nonhatching eggs and salvage value of flock credited

hatching eggs when egg production begins the 20th week, and 5 8% more when it is delayed until the 30th week

Recommendation The most economical and profitable age for a flock of meat type birds to attain 5% egg production on a hen-day basis is 24 weeks If the strain produces large eggs, the week could be the 23rd

BEST AGE FOR FIRST EGGS FROM EGG TYPE BREEDERS

Studies similar to those involving meat type breeders have been made for egg type breeders Although egg type, commercial pullets producing market eggs should attain 5% egg production when they are about 22 weeks of age, the female parent breeders of most egg lines produce smaller eggs Therefore, it is economically advisable to delay their onset of egg production They should reach 5% egg production when 23 or 24 weeks of age Such a delay in the start of production usually will necessitate controlled feeding and light management during the growing period

VARIATIONS IN WEEKLY MEAT TYPE HATCHING EGG COSTS*

The actual cost of producing a dozen meat type hatching eggs varies throughout the laying year The figure is high for the first few weeks of egg production, reaches a low level during the period of highest egg production, then increases toward the end of the laying cycle

These variations represent one of the major discrepancies in any analysis of meat type hatching egg production costs There are several important reasons for the variations

(1) The number of birds does not remain constant, mortality takes its daily toll

*From an article by the author, *POULTRY MEAT*, September, 1970

(2) The rate of egg production varies each week.
(3) Feed consumption varies according to egg production.
(4) Pullet growing costs must be amortized over the entire production period.
(5) The salvage value of the "spent" hen is variable, yet must be credited to egg production costs
(6) The length of the laying period is not uniform; some flocks are sold at a younger age than others

Weekly Cost Breakdown

Table 16.12 shows the variations in the cost of producing a dozen meat-type hatching eggs through 41 weeks of *total* egg production. The average cost in this

TABLE 16 12

ESTIMATED MEAT TYPE HATCHING EGG COSTS, BY WEEKS
(In U S dollars)

Week of Egg Production	*Hatching Eggs* Produced by 1,000 Pullets Housed, per Period Dozens	*Total Cost to Produce* One Dozen Hatching Eggs, per Period (Males Included)
1-4	250	$2 18
5-8	1417	0 63
9-12	1667	0 56
13-16	1500	0 57
17-20	1416	0 60
21-24	1250	0 62
25-28	1167	0 65
29-32	1000	0 68
33	236	0 69
34	230	0 70
35	219	0 72
36	214	0 73
37	206	0 75
38	195	0 77
39	190	0 79
40	179	0 82
41	173	0 85

analysis is $0.67 during the 41-week egg production cycle. The weekly variations are the important feature; the *first month the cost figure is $2.18 per dozen*, drops to $0.56 between the 9th and 12th weeks, then rises to $0.85 the 41st week.

Table 16.12 shows that during only two weeks of the egg production period do the birds produce hatching eggs at a cost comparable with the average cost for the laying period. These are the 6th and 31st weeks. From the data and analysis it is obvious that there is a great difference in the weekly cost of producing a dozen hatching eggs; during the weeks of high cost, it is 52% greater than during the low-cost weeks. This is a tremendous variation, and unless corrections are made to relate these facts, decisions regarding problem flocks and management factors cannot be made intelligently.

VARIATIONS IN WEEKLY LEGHORN HATCHING EGG COSTS

The variations in the weekly cost of producing Leghorn hatching eggs are not as great as with meat type breeders Differences in rate of lay, length of the production period, feed and other costs and salvage value are responsible for more uniformity Table 16 13, constructed on a basis similar to Table 16 12, shows these cost changes throughout the laying cycle The average cost of producing a dozen hatching eggs in this example is $0 48

TABLE 16 13

ESTIMATED LEGHORN HATCHING EGG COSTS
(In U S dollars)

Week of Egg Production	Hatching Eggs Produced by 1 000 Pullets Housed per Period Dozens	Total Cost of Producing One Dozen Hatching Eggs per Period (Males Included)
1–4	166	$1 67
5–8	1333	0 47
9–12	1500	0 43
13 16	1333	0 43
17–20	1333	0 44
21–24	1417	0 45
25–28	1333	0 47
29–32	1317	0 49
33–36	1310	0 51
37–40	1205	0 53
41–44	1190	0 57
45–48	1130	0 60
49–52	1083	0 63

WHEN TO SELL THE MEAT TYPE BREEDER FLOCK*

At the end of the laying period the meat-type breeder flock must be liquidated (sold) By that time egg production has dropped to a low level, hatchability is lower, and mortality has reduced the number of birds in the flock Obviously, each item increases the cost of producing hatching eggs But how long can the flock be kept at a profitable level before it is sold? Few bookkeeping procedures will give the answer, and many poultrymen resort to some haphazard method of making the determination

When the breeder flock is sold after the end of the egg production period, there is a cash return based on the market value of the birds This is a credit to the cost of producing hatching eggs An equal portion of this income must be credited back against the cost of each dozen hatching eggs produced, to get a true picture of the cost of producing hatching eggs on a weekly basis

In Table 16 14 the average cost of producing a dozen hatching eggs has been calculated from 16 weeks through 50 weeks of production For example, if the flock were liquidated at the end of 20 weeks of egg production it would have cost an average of $0 809 to produce a dozen hatching eggs to that time If it were liquidated at the end of 41 weeks, the cost of all hatching eggs produced would

*From an article by the author *POULTRY MEAT* July 1970

TABLE 16 14

AVERAGE COST OF PRODUCING ONE DOZEN MEAT TYPE HATCHING EGGS AND COST DURING LAST WEEK OF EGG PRODUCTION
(In U S dollars)

Week of Egg Production the Flock Was Sold	Average Cost of Producing One Dozen Hatching Eggs through Respective Week	Cost of Producing One Dozen Hatching Eggs Week before the Flock is Sold
16	$0 934	$0 863
20	0 809	0 758
24	0 744	0 716
28	0 703	0 689
32	0 680	0 710
33	0 677	0 713
34	0 673	0 720
35	0 671	0 738
36	0 669	0 746
37	0 667	0 760
38	0 666	0 786
39	0 665	0 798
40	0 666	0 829
41	0 667	0 848
42	0 668	0 868
43	0 669	0 889
44	0 670	0 913
45	0 672	0 940
46	0 673	0 969
47	0 676	1 001
48	0 679	1 025
49	0 682	1 053
50	0 685	1 117

have been $0 667 per dozen The table shows that costs drop from the 16th week until the 39th week, then increase

However, cumulative costs are not the entire answer to the question Obviously higher costs at the end of the production period are being diluted by lower costs at the beginning The cost of producing hatching eggs the week before the birds are to be liquidated is also given in Table 16 14 Here the variations are great For example, if a flock were liquidated at 32 weeks of age the cost the 32nd week would be $0 710 per dozen, if it were liquidated at 47 weeks of age the cost would be $1 001 per dozen the 47th week

Obviously, there must be a most economical age to sell meat type breeders Because of variable costs—pullet growing cost and salvage value of the flock—it is impossible to give the exact week when a given flock must be sold to produce eggs at the lowest cost, but it is obvious it must be somewhere near the 39th week of egg production, which would mean 36 to 37 weeks of hatching egg production But the 39th week cannot be taken as absolute, no 2 flocks are alike Some are better than average, some poorer, thus the most profitable time to sell the breeder flock will vary Good flocks, either because of better egg production or better hatchability, may be kept longer, poorer flocks should be liquidated sooner The important thing to keep in mind is that the weekly production costs increase vary rapidly at the end of the laying period, though cost increases for the entire laying period are not so pronounced Profits made on the flock during the early part of the laying period should not be unduly diluted by losses the last few weeks

Cage Management

This chapter deals with those procedures necessary to grow and keep egg type layers in cages This system of management is not new, although there have been numerous changes through the years As early as the 1930's, chickens were kept in cages At first, small coops with wire floors and a heating device were used for growing birds where the weather was mild, laying pullets were "housed" in small units soon afterward The first laying cages held one bird, sometime later multiple bird cages were introduced

It is now estimated that from 60 to 65% of all the *commercial* layers in the world are kept in cages Undoubtedly, most of the construction of new laying operations involves the cage method rather than the littered floor system

The success of cages has been due to the ability of the chicken to adapt to a small space Innovations to make the birds more comfortable and to reduce the labor of caring for the pullets have brought variations in cage systems, but the basic principles remain the same There are many cage systems in operation today, each varying in some manner from the others To give the recommendations for each type or system is impossible, only averages or generalities can be given in this short space

Cages have their advantages and faults Usually pullets in cages have less mortality than those on a littered floor, they are free from coccidiosis, the labor requirement is less, and the eggs are cleaner However, the initial investment per bird may be greater than when pullets are kept on a littered floor, egg production is less, and the fly problem creates a greater nuisance But in spite of the disadvantages, cage operations seem to produce greater profit in this age of modernized poultry production

BROODING GROWING CAGES

Not all cage operations keep the pullets on a wire floor from one day of age until they reach sexual maturity There are four combinations for using a littered floor and a wire floor during this period

(1) wire brooding, litter growing,
(2) litter brooding, wire growing,
(3) two house, wire brooding and growing,
(4) brooding-growing continuous cage

Brooding Cage Specifications

These specifications vary widely according to the manufacturer of the equipment and the procedures used for brooding and growing Usually, however, the chicks are started in one battery cage containing a heating unit Later, some of the growing birds are moved to one or more cage batteries, thus allowing more floor space as the birds become older

Brooding cage size Although brooding cages usually are used for growing birds as well as for young chicks, and are about 14 to 16 in (35 6-40 6 cm) high, the size of the floor varies Some common sizes are

22 in wide × 14 in deep (55 9 × 35 6 cm)

22 in wide X 24 in deep (55 9 X 61 0 cm)
24 in wide X 24 in deep (61 0 X 61 0 cm)
24 in wide X 27 in deep (61 0 X 68 6 cm)
24 in wide X 36 in deep (61 0 X 91 4 cm)

Floor material The floors of the brooding cage are made of

Welded wire fabric The mesh size usually is 1/2 in X 2 in (1 3 X 5 1 cm) or 1 in X 1-in (2 5 X 2 5 cm) The wire size is about 14 gauge When the mesh size is greater than 1/2 in , the floor will need to be covered with paper for the first two weeks

Perforated steel plates

Plastic This material is either entirely plastic or plastic covered wire

Slope of floor The floors of most cage brooding units do not slope, but some slope slightly upward at the front near the feeder

Front of cage In most instances, feeding is done at the front of the brooding cage, nearest the aisle The front of the cage is adjustable, this provides access to the feeders while preventing the chicks from getting out of the cages By adjusting the size of the opening through the wire, birds of various sizes may use the feeders

Gates Gates are built into the brooding cage to make it possible to put the chicks into the unit, and to take them out The gates may be on the front or on the top of the cage

Heating units Unless warm room brooding is used, it will be necessary to provide some supplementary brooding heat Although there are several arrangements, a hot water pipe is a common installation The pipe runs lengthwise of the house, above the back of each cage unit

Waterers Cups, drip nipples, troughs, and other arrangements are used to supply water Regardless of the type used, the height should be adjustable to be satisfactory when the birds are larger

Feeders The trough type of feeder is in predominate use during the brooding period It may be filled manually or automatically Some method of adjusting the height is preferable

Growing Cage Specifications

Because brooding cages are usually used for growing as well as brooding, the specifications are similar In some instances, however, there are separate growing units which are installed in buildings different from the brooding houses

Cage size In most instances, this is the same size as the brooding cage Because of the age and size of the birds, however, fewer birds are placed in each unit

Floor The mesh size of the wire on the floor of the cage should be large enough to allow the droppings to fall through easily There are many sizes in use The floor should be flat, or nearly so

Waterers The types of waterers are those employed with brooding units, but their height is greater

Feeders For growing birds, trough type feeders are the most common They may be filled by hand or automatically In the latter case, the troughs need not necessarily be outside the cage, some are in the center, allowing the birds to eat from both sides Troughs are about 5 to 6 in (12 7-15 2 cm) wide, with a good lip that helps prevent feed wastage

Two house, Wire Brooding and Growing

With this system, one house or unit is used for brooding, the second and larger house is devoted to growing There are advantages and disadvantages to this system of management

Advantages

(1) The system utilizes the smallest amount of floor space, particularly when the multideck units are used

(2) Cage construction is simplified, resulting in a lower cage cost

(3) Brooding heat costs are low because of the high bird density in the brooding house

Disadvantages

(1) Length of time the houses are empty is greater between broods, often increasing the growing cost

(2) Close scheduling of facilities to reduce downtime (vacant time) may lead to difficulties in providing time for cleaning between groups of birds

(3) There is the added stress of moving birds from one house to another

Brooding-growing Combination Cages

With this program, the birds are kept in the same house or unit from one day of age to the time they are moved to the laying location The cages are large enough for growing birds, but some of them are used for brooding Again, there are advantages and disadvantages

Advantages

(1) The birds are not moved to another house, therefore the stress associated with the transfer is reduced

(2) The downtime usually is shorter

(3) Labor costs may be lowered, because some of the vaccinating, along with the debeaking, may be done when the chicks are transferred to larger cages

Disadvantages

(1) In most cases the unit may be more expensive than with the two-house system, but a lot depends on the location of the brooding units in the combination house

(2) The house is cooler during the brooding period because of its larger size

Number of decks Some brooding-growing systems employ the use of one deck, some two decks, and some three decks

(1) Single-deck Most of the new installations do not use the single-deck, brooding-growing units The housing cost is greater because of the reduced bird density in the building

(2) Two-deck About 21 chicks are started in each cage in 1 deck Supplementary heat is supplied to this deck At 6 to 8 weeks of age half the chicks in each cage are moved to a cage above or below the heated one

(3) Three-deck Approximately 36 chicks are placed in a heated cage at starting time Later, one third of the birds are moved to a cage above or below, and when they are about six weeks of age half the remaining chicks in the brooding unit are moved to the empty cage

Manure disposal: Droppings fall through the mesh bottom of the cage to the floor below. Although this is a simple procedure when there is but one deck of cages, and with two decks when the upper deck is not directly over the lower, there is a problem with the three-deck cage, as the upper two decks will overlap the deck below. To prevent the droppings from falling on the birds in such cases, a sloping droppings board is inserted under the wire floor. In most cases this slopes toward the center of two lines of cages, and the droppings fall to a common place in the center of the floor.

Removing manure from the floor Although a concrete floor is not necessary under cages, it does aid when it becomes necessary to scrape up the manure from the floors. Most of these scrapers involve some automation, a power cart or small tractor pulls or pushes a scraper across the floor under the cages. There should be no cage-supporting posts to interfere with the procedure. For this reason, many cages are hung rather than supported by posts.

Deep pit system of collecting droppings The pit system for cage operations is becoming popular. Walks are constructed between the cages for service work, but the area under the cages is open, allowing the droppings to fall into a deep pit which may be easily cleaned

BROODING GROWING CAGE HOUSES

The width of the brooding-growing house must be determined by the dimensions of the cages that go into it In some mild climates, little housing may be required, "housing" is confined to a suitable roof with curtains on the sides These curtains are to be used only during the first few weeks, and during inclement weather

High Chick Density

It is obvious that double-decking and triple-decking increase the density of the birds in the house. There must be ample ventilation See Chapter 11 In moderate or cold climates, the environmentally controlled house is the best means of providing a constant flow of fresh air, and the elimination of moisture and ammonia fumes

Remember Because pullets grown on wire floors in cages require much less floor space than do those which are raised on a littered floor, there may be from 3 to 5 times as many birds in the house, depending on the age of the birds and the type of cage construction

Cooling the brooding-growing house With so many birds in the cage house there usually will be difficulty in keeping the house temperature at optimum. Even with the open sided house, there may be problems. In the environmentally controlled building the use of pad-and-fan cooling is the best means of producing lower house temperatures. See Chapter 11.

CAGE BROODING MANAGEMENT

Preparing the cage house for new pullets follows the procedures outlined for the house with a littered floor. Cleanliness and a good start are important. Isolation of the brooding unit should be made a part of the management program. All chicks should be the same age. Practice the all-in, all-out system.

Number of Chicks Per Cage

Conventional type Leghorn pullets and medium-size pullets (raised for the production of brown-shelled eggs) are the types common to cage operations Although the mini Leghorn is produced by a few poultrymen, experimental work has not proceeded far enough to offer many recommendations for this breed The size of the brooding cage will determine the number of chicks that can be brooded in each unit, but the floor space required by each chick is quite constant as follows

Leghorns (conventional)	24 sq in (155 sq cm) per chick to 6 weeks of age
Medium-size	28 sq in (181 sq cm) per chick to 6 weeks of age

Supplemental Heat

When the heat from a hot water pipe is used for supplying supplementary heat to the brooding unit, the water should be kept at a temperature of about 180°F (82 2°C) Often one pipe will supply heat for two cages when they are placed back to back Heavy, reflector type paper may be placed over the top of the pipe to deflect heat into the brooding cage Some units have a deflector built into them Maintain a temperature of between 82° and 85°F (27 8°-29 4°C) about 2 in (5 1 cm) above the floor, and in the locality of the heated area *Chicks should not huddle if the temperature is correct*

Paper on Cage Floor

Paper is often laid on the wire floor and kept there for about two weeks It should be heavy, rough, and highly moisture proof This paper serves several purposes

(1) provides a solid floor when the chicks are young,
(2) allows for the use of wire with larger openings,
(3) keeps the brooding area warmer,
(4) serves as an area for the first feed

Watering

Chicks should drink quickly once they are placed in the cage brooder, as on the littered floor Many times the watering devices are not applicable to day-old chicks, the birds have difficulty in learning to drink from nipples, certain cup founts, and others It is often necessary to provide jug and pan type waterers the first several days

Watering devices should be adjustable so they can be lowered when the chicks are young, and raised as they grow older

Water sanitizers Sanitizers may be used in the drinking water, but take the usual precautions to provide clean water and clean founts when administering any vaccine through the drinking water See Chapter 43

Room Temperature

Cage brooding requires a relatively high room temperature It should not be allowed to drop below 60°F (15 6°C) This promotes chick comfort and reduces the cost of providing the supplementary brooder heat But do not allow the room temperature to get too high *Remember* that chicks do not normally feather as well on wire as they do on litter, and high temperatures induce cannibalism Provide adequate ventilation and house cooling when necessary to minimize the effects of high outside temperatures

Light

It is much more difficult to provide uniformity of light intensity in cage operations than in floor systems. This problem is increased with multidecked cages, because the light intensity from a single bulb hung overhead is greater at the top deck than at the lower. Furthermore, shadows produced by the cages cut off a great deal of the light supply. In some specialized operations in mild climates, natural daylight may suffice for the birds to see to eat, but it cannot be used during a light-control program See Chapter 18.

Several factors affect the proper use of artificial light:

(1) Provide bright light continuously for the first four days the chicks are on feed so that they may get off to a good start by learning quickly to eat and drink.

(2) After the chicks are four days of age, gradually change the length of the light day (natural plus artificial light) according to a predetermined schedule. See Chapter 18.

> *Important* The light-control schedule is necessary to regulate the age at which the birds reach sexual maturity There are several lighting programs, but each poultryman must follow the one that will produce the best results under his system of housing and management.

(3) Generally speaking, the intensity of the light for growing pullets should be about one-half footcandle at the location of the lower cage deck. This will be adequate for normal feed consumption and will prevent a great deal of cannibalism. Many poultrymen are installing rheostats on their artificial lighting systems to regulate intensity accurately and easily.

Vaccination and Medication

There must be a satisfactory vaccination program with caged birds, as with those reared on the floor. Because of the house density, many diseases are more prevalent in cages. Respiratory diseases are especially common See Chapter 43 for suggestions regarding a vaccination program

Medication too is important, not only to treat disease outbreaks, but to handle certain nonspecific types of cage difficulties. Keep a record of all medications.

> *Be careful* Coccidiosis is almost completely obliterated when pullets are kept on wire from one day of age until they complete their laying cycle. *Remember*, however, that such birds do not build any immunity to the disease, as they have never come into contact with an ample number of sporulated oocysts If the pullets are moved from wire to litter, there is a great chance that coccidiosis will develop. Be sure some means of handling the coccidiosis problem is provided in such cases. Be ready to medicate quickly.

Dubbing and Debeaking

Some strains of chickens are endowed with large combs which are difficult for the birds to handle in cages. In some other cases there may have been severe injury to the combs of some of the birds while in the laying cages. Pullets so involved should be dubbed at hatching time.

Debeaking almost mandatory Cannibalism is prevalent when birds are confined to small cages, either during growing or laying There are several methods of reducing the incidence, of these, debeaking is probably the best and the most common Although pullets may be debeaked at almost any age prior to reaching sexual maturity, the process is best accomplished by precision debeaking when the chicks are 6 to 9 days of age See Chapter 13

FEEDING DURING THE BROODING PERIOD

Correct nutrition is detailed in chapters later in this book However, there are several feeding practices necessary for young chicks that should be discussed here

Form of Feed

Before receiving any chicks, the poultryman must make a decision regarding the form of feed to be used One has the choice of either mash or crumbles, but most chicks are started on mash Keep in mind that compressing a feed, as in the manufacture of crumbles, induces more cannibalism in cages

First Feed

Feed should be available when the chicks are first placed in the cage brooder units Many prefer to place a paper over the wire floor, and put the first feed on the paper where the chicks can find it easily With many brooder units however, the feeders are so located as to make it easy for the chicks to learn to eat

Feeder Space Requirement

The feeder space requirement during the first 6 weeks of life is about 1 in (2 5 cm) per chick Most brooding units provide this amount, or more

Full feed During Brooding

During the first six weeks, chicks are full fed In some brooding units the feed may be administered by hand, in others, it is supplied by automatic equipment Regardless of the system used, *feed must be available at all times Fill the feeders* brim full the first two days if paper is not used

Feed Consumption

Keep a daily record of feed consumption This will necessitate weighing the feed

Estimated feed consumption Many factors, such as the strain of the birds, composition of the feed, and the ambient temperature, influence the amount of feed consumed during the first six weeks As a guide, however, figures for weekly consumption are given in Table 17 1

CAGE GROWING MANAGEMENT

The length of the "growing" period depends on the age at which the mature pullets are placed in their permanent laying quarters It may vary between 17 and 22 weeks under most conditions, but occasionally pullets are placed in laying cages as young as 14 weeks of age In these cases the laying cage must be considered as a growing cage for several weeks

TABLE 17.1

WEEKLY FEED CONSUMPTION PER 100 PULLETS DURING FIRST SIX WEEKS

Week	Mini-Leghorn(1)				Leghorn (Conventional)				Medium-size(2)			
	Lb		Kg		Lb		Kg		Lb		Kg	
	Per day	Cumulative	Per day	Cumulative	Per day	Cumulative	Per day	Cumulative	Per day	Cumulative	Per day	Cumulative
1	2.1	14.6	0.95	6.6	2.9	20	1.32	9.0	3.6	25	1.60	11.3
2	2.9	35.0	1.32	15.9	4.0	48	1.81	21.8	5.6	65	2.59	29.5
3	3.9	62.8	1.77	28.5	5.4	86	2.45	39.0	6.1	108	2.77	49.0
4	5.1	98.5	2.31	44.7	7.0	135	3.18	61.2	8.7	169	3.94	76.7
5	5.8	139.4	2.63	63.2	8.0	191	3.63	86.6	9.1	233	4.13	105.7
6	6.1	182.5	2.78	82.8	8.4	250	3.81	114.0	9.5	300	4.31	136.0

(1) Based on 73% of conventional Leghorn.
(2) Producing brown-shelled eggs.

There are two types of growing cages:
(1) separate growing cage;
(2) brooding-growing combination cage

Separate Growing Cages

Cages of this type usually are placed in a separate growing house. There are many cage sizes, and each may hold between 10 and 35 pullets.

Floor space per pullet: The longer a pullet is held in the growing cage, the more floor space required per bird. Some strains of pullets need more floor space than others. The usual requirements are given in Table 17.2.

However, floor space is related to production results. As birds are crowded during growing, their weight decreases and they are prone to poorer egg production in the laying units. Some of these relationships are discussed later in this chapter.

TABLE 17.2

GROWING CAGE FLOOR SPACE REQUIREMENTS PER PULLET

Breed	To 14 Wk		To 18 Wk		To 22 Wk	
	Sq In.	Sq Cm	Sq In.	Sq Cm	Sq In.	Sq Cm
Mini-Leghorn*	24	155	30	194	40	258
Leghorn (conventional)	36	232	45	290	60	387
Medium-size	43	277	55	355	75	484

*Based on 66% of conventional Leghorn.

Brooding-growing Combination Cages

As stated earlier, these are units in which the chicks are started and grown to an age near sexual maturity. The units may be single-deck, double-deck, or triple-deck. In the latter two, the chicks usually are started in one cage unit; some of the birds are then moved to another unit or units when they reach six weeks of age. This provides the birds with more floor space as they grow older.

Growing Feeders

Feeding is done by hand or by automatic equipment Feed troughs are a part of most installations, and automatic devices force or drag the feed through the building, filling the feeders Feed carts are used to semiautomate "hand" feeding These are motorized, and feed is scooped up from a feed tank and added to the troughs by hand, or an auger and elevator lift the feed from the tank, after which it flows to the troughs by gravity

Growing Waterers

As with the waterers used during the brooding period, there are many types of small waterers capable of furnishing water to the small cages Cups, drip valves, and other devices are in use

Light

The length of the light day is very important during the growing period It must be regulated to cause the pullets to begin egg production at a desired age There are several programs, all are explained in Chapter 18

Vaccination and Medication

Vaccination and medication programs must be carried out carefully during the growing period Most of these start during the brooding phase, but continue as the pullets grow older Consult a trained poultry pathologist or your vaccine and medicine supplier for programs that are necessary in your area Some suggestions are given in Chapter 43

Cannibalism

When birds are given limited space, as in cages, there is a tendency for many to become cannibalistic Some means of preventing this vice must be initiated before trouble begins Debeaking is the most acceptable practice If the birds were not debeaked when they were six to nine days of age, their beaks should be cut back some time during the growing period Specs or beak guards are substituted for debeaking in some instances See Chapter 13

Music to quiet the pullets As with pullets grown on a littered floor, radio music offers a possibility for quieting the growing birds They are less apt to become frightened from unusual noises and the movements of the caretaker

FEEDING DURING CAGE GROWING

Adequate nutrition is necessary during the growing period, for it has a bearing on how well the pullet will develop and when she will reach sexual maturity These subjects are discussed in future chapters

Feeding System

Although most genetic breeders recommend full feeding of their egg laying strains during the growing period, there is an interest in controlling the feed intake in a manner similar to that used for the controlled feeding of meat type strains Obviously the feed restriction is not as great with egg type strains These programs call for weighing the daily feed allocations, a procedure worthwhile, regardless of the feeding system employed

Importance of body weight: Body weight offers an index of how rapidly growing birds are approaching sexual maturity. If the birds are too heavy, the daily feed allocation must be reduced. When the pullets are underweight, feed intake must be increased.

Cages and growing weight: The lack of exercise in cages has an effect on the body weight of the pullets regardless of their age. Birds gain more, and growing birds are heavier at maturity than those raised on littered floors, where they have more room to move about. Work at Cornell University (1969) showed that Leghorn pullets raised in cages had from 3 to 5% more fat in their body tissues than those raised on a littered floor and fed the same ration.

CAGE GROWING RESULTS

Although it is well to follow certain recommendations during the period growing birds are in cages, one should also understand what happens when variations from the recommendations occur. Many experiments have been conducted to point out these changes, and some of the results are given below.

Litter vs. Cage Rearing

The results of an experiment conducted at Storrs Agricultural College (1969) indicate the differences occurring during the growing and laying periods when Leghorns were kept on litter and in cages. The results showed that there was higher mortality on the floor during the growing period, but it was lower during the laying period.

TABLE 17.3

EFFECT OF THREE LEGHORN PULLET-GROWING PROGRAMS ON LAYING PERIOD PERFORMANCE
21 to 65 weeks of age

Growing Program	Hen-day Egg Production %	Feed per Dozen Eggs Lb	Feed per Dozen Eggs Kg	Mortality per Month %
Littered floor, 0-21 wk	75.7	3.72	1.69	1.8
Litter to 8 wk, cages to 20 wk	74.4	3.64	1.65	1.5
Cages, 0-20 wk	74.2	3.64	1.65	1.1

Source: Storrs Agricultural College.

Crowding in Growing Cages

In *Poultry Tribune* (January, 1969), Donald Bell reported the results of field trials having to do with crowding birds in growing cages and the effect on body weight. Various numbers of Leghorn pullets were placed in 24-in. × 24-in. (61 × 61 cm) cages at one day of age and weighed at different ages. Floor space per pullet varied between 96 sq in. (619 sq cm) and 29 sq in. (187 sq cm). Body weight at 16 weeks was not materially affected until the pullets were kept in less than 58 sq in. (374 sq cm) of floor space, after which weight decreased as floor space was reduced. From an economical standpoint, it seemed evident that a 24-in. × 24-in. (61 × 61 cm) cage could accommodate 14 Leghorn pullets to 16 weeks of age.

TABLE 17.4

EFFECT OF CAGE FLOOR SPACE AND 16-WEEK BODY WEIGHT

	Data for Each 24 In. × 24 In. (61 × 61 Cm) Cage							
Pullets per cage	6	8	10	12	14	16	18	20
Sq in. floor space per pullet	96	72	58	48	41	36	32	29
Sq cm floor space per pullet	*619*	*464*	*374*	*310*	*265*	*232*	*206*	*187*
First test								
Body weight, 16 wk (lb)	2.79	2.64	2.70	2.57	2.50	2.45	2.38	2.26
Body weight, 16 wk (kg)	*1.27*	*1.20*	*1.23*	*1.17*	*1.13*	*1.11*	*1.08*	*1.02*
Second test								
Body weight, 16 wk (lb)		2.22	2.22	2.15	2.13	2.06		
Body weight, 16 wk (kg)		*1.01*	*1.01*	*.98*	*.97*	*.93*		

Source: D. Bell, *Poultry Tribune*, Jan., 1969.

Uniformity of Cage-grown Pullets

Uniformity of body weight of laying type pullets at sexual maturity is difficult to define. It varies by strains. However, under most conditions 75% or more of the pullets should be within 10% of the average weight of the flock.

Examples:

(1) Leghorn pullets

Average flock weight at sexual maturity is 3.2 lb (1.45 kg). Therefore 75% or more of the pullets should weigh between 2.88 and 3.52 lb (1.31–1.60 kg) if the flock is "uniform."

(2) Medium-size pullets

Average flock weight at sexual maturity is 4.0 lb (1.8 kg). Therefore 75% or more of the pullets should weigh between 3.60 and 4.40 lb (1.63–2.00 kg) if the flock is "uniform."

LAYING CAGES

The use of laying cages for commercial egg production has become exceptionally popular. But cages are not a panacea for all the problems arising; there are advantages and disadvantages.

Advantages of laying cages:

(1) It is easier to care for the pullets; no birds are underfoot.
(2) Floor eggs are eliminated.
(3) Eggs are cleaner.
(4) Culling is expedited.
(5) In most instances, less feed is required to produce a dozen eggs.
(6) Broodiness is eliminated.
(7) More pullets may be housed in a given floor space.
(8) There is no litter problem.

Disadvantages of laying cages:

(1) The handling of manure may be a problem.
(2) Generally, flies become a greater nuisance.
(3) Pullets lay fewer eggs in cages than when kept on a littered floor.

(4) The investment per pullet may be higher than in the case of floor operations
(5) There is a slightly higher percentage of blood spots in the eggs
(6) The bones are more fragile and processors often discount the fowl price When the condition is serious there may be no market for the spent hens

Laying Cage Size

Although the height of most laying cages is quite similar at 16 in (40 6 cm) at the shortest distance (cage floors slope), the size of the floor area is highly variable Some common floor sizes are

In	Cm
8 × 16	20 3 × 40 6
10 × 16	25 3 × 40 6
12 × 16	30 5 × 40 6
12 × 18	30 5 × 45 7
12 × 20	30 5 × 50 8
14 × 16	35 6 × 40 6
14 × 18	35 6 × 45 7
16 × 18	40 6 × 45 7
16 × 24	40 6 × 61 0
24 × 18	61 0 × 45 7
24 × 36	61 0 × 91 4
36 × 48	91 4 × 121 9

Types of Cages

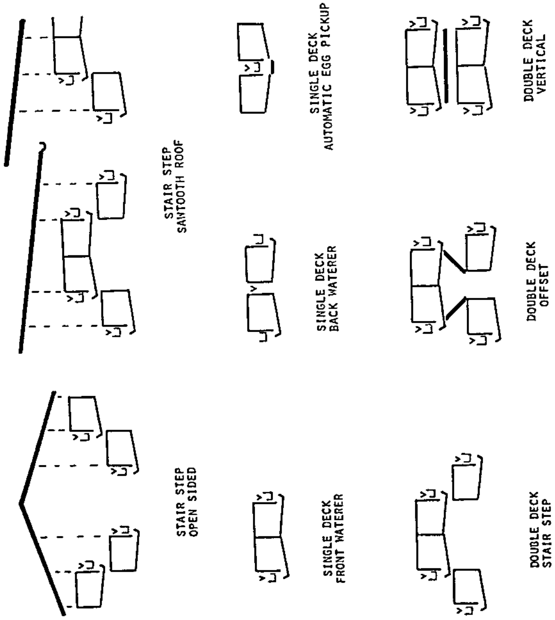
Since the advent of laying cages, not only have the floor sizes fluctuated, but the method of arranging the cages in the house and the number of birds per cage have become highly variable

Cage systems These may be categorized according to the number of birds in a cage, as follows

(1) *Single bird cages* The first laying cages were suited to one bird, but because the cage investment is high, seldom are single bird cages used today
(2) *Multiple bird cages* These laying cages hold 2 or more pullets, usually not more than 8 or 10
(3) *Colony cages* These are large laying cages suitable for holding between 20 and 30 pullets

Cage arrangement To conserve space, thereby reducing the investment in the house in which the laying cages are placed, many methods have been originated to get more cages in a given area This has led to the following general classification of cage arrangement

(1) *Single deck* Placing but one tier of cages in a house produces a high housing investment The arrangement is practical only in areas with a warm climate where the "house" consists of nothing but a roof
(2) *Double deck* These are popular because the upper deck is offset,


STAIR STEP
SAWTOOTH ROOF
SINGLE DECK
AUTOMATIC EGG PICKUP
DOUBLE DECK
VERTICAL
SINGLE DECK
BACK WATERER
DOUBLE DECK
OFFSET
STAIR STEP
OPEN SIDED
SINGLE DECK
FRONT WATERER
DOUBLE DECK
STAIR STEP

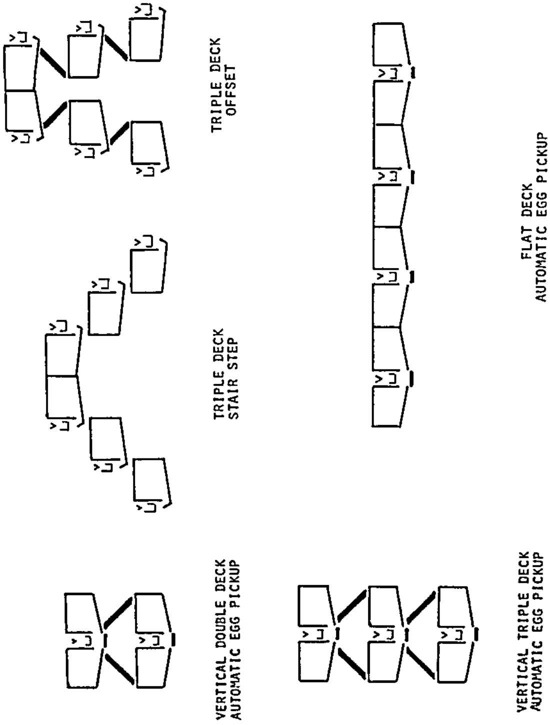


FIG. 17.1. SOME CAGE ARRANGEMENTS

allowing the droppings to fall through the wire mesh to the house floor without touching the lower deck The offset arrangement is often called the *stair step system*

(3) *Triple deck* To conserve house space still further, three decks are common However, the upper two decks are only partially staggered or not staggered at all To prevent the droppings from falling on the birds below, tilting droppings boards are installed below the top two cages, causing the manure to fall into one area

(4) *Flat deck* Although these are single-deck cage installations, the cages are placed close together without a walkway for servicing the pullets All such work is done from a motorized catwalk that moves back and forth over the cages

Laying Cage Floors

Most material for laying cage floors is welded wire fabric, although there are some innovations Sometimes the wire is coated with plastic All laying cage floors slope so that the eggs roll to a collection area or onto a movable belt

Cage wire Most cage floors are constructed of 14-gauge wire to give the necessary strength With colony cages, however, the floor wire is stretched over many supports to give added strength and evenness Sometimes such colony cages are known as *stretched wire cages*

Most cage floors are constructed of wire with a mesh size of 1 in by 2 in (2 5 X 5 1 cm) The uppermost wire must run at right angles to the length of the house, or from the back to the front of the cage, so that the eggs will roll off the cage floor easily

Egg collection Laying cages are constructed with a sloping wire floor which causes the eggs to roll to the front or back of the cage, the front being closer to the service aisle The wire should slope about 2⅝ in (6 7 cm) for each 16 in (40 6 cm)

Gathering eggs by hand When eggs are to be collected by hand, the wire floor should be extended past the front of the cage and rounded so as to act as a collection basket for the eggs In some instances the wire at the point of collection is machine formed, to slow down the speed of the eggs as they roll to the front, thus avoiding some breakage A rubber or plastic bumper is sometimes added at the front of the collection area to further reduce breakage

Floor construction and egg breakage There is evidence to show that the steeper the slope of the wire, the higher the percentage of cracked eggs Furthermore, the farther the eggs have to roll, the greater the breakage A larger mesh size will produce less egg impact when the egg is laid, thus reducing breakage

Automatic egg collection To reduce the labor requirement of egg gathering, automatic devices have been developed Although there are some variations, the procedure is standard, a movable belt about 4 to 5 in (10.2–12 7 cm) wide is used to transfer the eggs from the collection area at the base of the wire cage floors to a central location at the end of the poultry house To reduce the number of belts in a house, placement of the cages is usually reversed, so that one belt picks up eggs from two

lines of cages. Belts must be kept clean to prevent the eggs from becoming dirty during transfer; therefore some soft, impervious, and washable material must be used.

Feeders for Caged Layers

Long, continuous troughs are used almost universally for feeding caged layers. Since the troughs are usually located on the outside of the cage, the birds must reach through a "feeder fence" to feed. The troughs may be filled by hand or automatically, but the method changes the arrangement of the cages within the house.

Hand feeding When the birds are fed by hand there must be a service aisle between the rows of cages Feed troughs are hung on the front of the cages, next to the aisle The distance between the aisle sides of the troughs should be 28 in. (71 1 cm), inasmuch as motorized equipment is driven through the aisles, and this equipment is built for this width The long troughs extending the length of the cage units should have no partitions, as feed in the troughs is often supplied by a shute, or is stirred by running a stick or paddle inside the trough, and any partitions prevent an easy operation. Most troughs are made of metal, but some are of plastic. Although it is not necessary to adjust the height of the troughs after the birds are placed in the cages, most cages have a clamp that may be set to hold the trough at a required height. A distance of about 9 5 in. (24.1 cm) above the floor is about right.

Mechanical feeding There are several methods of moving feed through the cage house to keep the troughs full To reduce the amount of automatic feed equipment, cages are placed so that one auger or chain will service 2 rows of cages by placing the feeding area at the back, between 2 rows Aisle width is normally less when mechanical feeding is used. This may alter the construction of the cages, stair-step arrangement does not lend itself to reduction in the amount of automatic equipment as well as cages placed one above the other. With the flat-deck system, one feeder services two rows of cages, but there are no service aisles

Waterers for Caged Layers

Water is supplied by troughs running the length of the cage unit, cups, or drip nipples When the long trough is used, water runs continuously in a small "V"-shaped (or similar) trough. Cups or drip nipples may be placed in each cage; or sometimes they may service two adjoining cages, depending on the number of birds in a cage.

Location of the trough waterer The long, continuous water trough usually is placed above the feed trough outside of the cage. The reasoning behind this recommendation is to prevent any spilled water from dripping on the eggs in the egg-holding reservoir, the feed trough acting as a catch basin. In many instances, 1 trough serves 2 lines of cages, placed back to back. There must be some way of adjusting the level of the trough so that the water flows evenly and smoothly. The trough level will be higher where the water enters than at the end of the line where the water leaves.

LAYING CAGE HOUSES

There must be some protection for the caged layers In mild climates, with no freezing weather during the winter months, this may be no more than a roof over the cages But where the weather is colder, complete housing must be provided Because of the high bird density in cage operations, adequate ventilation must be provided to bring fresh air into the building and to exhaust the heat and ammonia fumes Environmental control is becoming an accepted practice in house construction Totally dark houses with pad and fan cooling are used extensively

Cage House Width

The width of the house (or roof in mild climates) is determined by the size and construction of the cages placed in it Poultry equipment manufacturers will supply these dimensions along with other details of house construction

Remember Cages increase the number of birds in a house, therefore ventilation must be greater than when birds are kept on the floor Leghorn layers on the floor are usually provided with approximately 1 75 sq ft (0 16 sq m) of floor space With some cage installations the density in the house may be five times as great

Shape of the Roof

In mild climates, where only a roof is needed to supply protection from the sun and the rain, the gable roof is common The width of the roof will be determined by the number of cage rows to be placed beneath it When the installations become large, the sawtooth roof is advantageous, as it provides good ventilation in the middle of the building and is easier to construct

In cold climates where environmental protection is needed, the gable roof is used almost exclusively

Environmentally Controlled Houses

The basic rules as outlined in Chapter 11 are used in the construction of environmentally controlled cage houses However, the amount of air to be moved through the house is greater, and this calls for more ventilating fans

The Deep-pit Cage House

Because of problems with manure removal and resultant pollution, many new cage operations in colder climates incorporate a deep pit in their house construction, only walkways serve as the floor, the droppings falling directly into the pit These pit houses have advantages and disadvantages

Advantages

(1) Postpones the removal of the droppings
(2) Requires less labor for manure removal
(3) Keeps the bird area of the house cleaner

Disadvantages

(1) Creates a problem from rodents unless the house is very tight
(2) Building costs are greater because of the pit construction
(3) Water leakage in the pit will cause anaerobic bacterial action, producing unusual odors and lowering the value of the manure

Ventilating the deep pit cage house Although ventilating the deep pit conventional house with a slat floor is relatively easy, the high bird density in

the cage house intensifies the problem of good ventilation. Actually, there are two buildings to ventilate: the upper, containing the birds, and the lower, containing the manure. The birds create more heat in the house because of their number; the water in the large quantity of droppings creates a moisture problem. Seemingly, it is easy to provide adequate air movement for the birds with the slot type of air intake and exhaust fans in the pit. However, the exhaled moisture from the birds may become so great at times that once the air drops into the pit it will pick up little additional moisture. In such cases it may be necessary to force air into the middle of the pit through a long tube with holes cut in the sides. In very cold areas this air may have to be heated.

Odors from pit manure may be reduced by the use of one of the chemicals on the market for treating poultry manure.

MOVING PULLETS TO LAYING CAGES

Pullets to be placed in laying cages may have been raised on a littered floor or in a growing cage with a wire floor. Care should be taken at moving time to handle the birds carefully, to lower the incidence of stress.

Age When Moved

Pullets may be transferred to the laying cages at any age between 14 and 22 weeks. Seventeen to 18 weeks seems to be the optimum so far as the birds are concerned. The birds are in the laying cages sufficiently early to recover from moving stresses prior to the time egg production begins. But growing facilities may dictate moving at other ages. Sometimes the facilities may not be great enough to allow the birds to remain in the growing quarters until 17 or 18 weeks of age; in other cases, the laying quarters may not be available until the growing pullets are older.

Sorting the Pullets by Weight

Obviously, all pullets are not of equal sexual maturity when they are placed in the laying cages; some will begin egg production sooner than others. Since body weight is a good criterion of sexual maturity within a given flock, some poultrymen have placed smaller birds together within a cage, birds of average size in others, and the largest pullets in other cages. The University of Georgia conducted an experiment in which the weight segregations of Leghorn pullets by cages was but one-fourth pound (113.5 gm). Results showed that the smallest and the largest birds when caged separately produced the lowest number of eggs. The smallest pullets came into egg production last. Best egg production came from birds close to the average weight of the entire group. The data also showed that the birds that were segregated by weight produced 1% more eggs than the group not segregated, but they also had 1.4% more mortality on a hen-housed basis. This would indicate that sorting by weight at caging time is not an economical procedure.

CAGE LAYER MANAGEMENT

Although the handling of layers in cages seems an easy procedure, many management factors have a bearing on the economy of egg production.

TABLE 17 5

EFFECT OF SORTING LEGHORN PULLETS BY WEIGHT AT CAGING TIME

Body Weight at 19 Weeks of Age Lb	Kg	Percent of Pullets in Each Weight Classification	Percent Egg Production
2 26-2 50	1 03-1 13	1	36 2
2 51-2 75	1 14-1 25	7	43 2
2 76-3 00	1 25-1 36	21	57-63
3 01-3 25	1 37-1 47	33	57-63
3 26-3 50	1 48-1 59	23	57-63
3 51-3 75	1 59-1 70	12	57-63
3 76-4 00	1 71-1 81	3	53 7

Source J H Massey, 1969 *Southeastern Poultry Times*, Jan 29

Cage vs. Floor Operations

There is quite a variation in the behavior of layers in cages compared with those kept on a littered floor. Although the differences are highly variable depending on the density of the birds within a single cage, a comparison of cage vs. littered floor operations shows the following·

(1) The investment per caged bird is 50 to 100% greater.
(2) Caged layers produce fewer eggs, usually about 12 less in 52 weeks of lay, but crowding birds in cages reduces egg production still further.
(3) Eggs from birds kept in cages are slightly heavier.
(4) Mortality is usually lower in cages
(5) Some strains adapt themselves to cages better than others
(6) Eggshell quality deteriorates more rapidly when layers are kept in cages.
(7) Interior egg quality drops off more quickly in the case of caged layers.
(8) Labor requirements for cage operations are about 50 to 80% of those for floor management The difference depends on the degree of automation
(9) Caged pullets weigh more at end of laying year, but their market value is less

Types of floor compared Work at Pennsylvania State College showed the variations that occurred when two types of floors were compared with various cage densities Some of the figures are given in Table 17.6.

TABLE 17 6

LITTER AND SLAT FLOORS VS CAGE DENSITIES

Item	Litter Floor	Slat Floor	Number of Leghorns per Cage 1	2	3	20
Floor space per pullet (sq ft)	1 30	1 00	1 34	0 83	0 67	0 64
Floor space per pullet (sq in.)	187	144	193	120	96	92
Floor space per pullet (sq m)	*0 12*	*0 09*	*0 13*	*0 08*	*0 06*	*0 06*
Eggs per pullet	220	216	207	206	205	203

Source T A Carter, 1969, Pennsylvania State Univ , University Park, Pa.

TABLE 17.8

LEGHORN LAYER DENSITY IN A 12 X 18 IN (30 5 X 45 7 CM) CAGE
(305 days of egg product on)
(In U.S Dollars)

Number Pullets per Cage	Floor Space per Pullet Sq in.	Sq cm	% Mortality	Feed per Dozen Eggs Lb	Kg	Eggs per Hen	Income over Costs per Pullet
2	108	697	9 60	4 02	1 82	230	$0 067
3	72	464	8 25	4 09	1 86	229	0 643
4	54	348	14 80	4 35	1 97	221	0 693
5	43	277	22 50	4 66	2 11	204	0 196

Source C E. Ostrader and R J Young 1969 Poultry Sci 48 No 5 1855.

(277 4 sq cm) of floor space, but at the end of the test each had 55 5 sq in (358 sq cm), which was more floor space than was provided at 4 per cage at housing time

Number of Pullets Per Laying Cage

The amount of floor space allowed each pullet at cage housing time is one thing, but the size of the cage is another, because it will determine the number of birds that can be placed in a cage As mortality within a cage increases, the floor space for each of the remaining pullets increases, and affects a recommendation for op timum cage size However, Louisiana State University tried to answer this ques

TABLE 17.9

PERFORMANCE PER LEGHORN PULLET WHEN VARIOUS NUMBERS OF PULLETS WERE KEPT PER LAYING CAGE
(330 days of egg production)

Item	Number of Pullets per Cage 1	2	5	10	20
	No Statistical Difference				
% egg production	62	61	59	62	59
Average egg weight (oz/doz)	25 2	25 1	25 0	25 2	25 2
Average egg weight (gm/ea)	*59 5*	*59 3*	*59 1*	*59 5*	*59 5*
% large eggs	75	73	74	75	76
Haugh units	78	77	78	78	77
% blood spots	2 1	1 7	2 2	1 3	2 0
% mortality	14 1	11 6	15 6	13 2	15 6
Feed per dozen eggs (lb)	4 5	4 5	4 6	4 5	4 7
Feed per dozen eggs (kg)	*2 04*	*2 04*	*2 09*	*2 04*	*2 13*
Income over feed cost (US$)	2 88	2 93	2 69	2 96	2 70
	A Statistical Difference				
Gain in body weight (lb)	1 21	1 30	1 31	1 43	1 47
Gain in body weight (kg)	*0 55*	*0 59*	*0 59*	*0 65*	*0 67*
% soft-shelled eggs	0 76	0 57	0 43	0 38	0 42
% broken eggs	0 37	0 30	0 47	0 51	0 72

Source B. A Tower 1969 Louisiana State Univ., Baton Rouge La.

tion in an experiment that eliminated increased floor space per pullet as mortality within the cage varied. In this test, each bird received 90 sq in. (580 5 sq cm) of floor space regardless of the number of birds in the cage. If a bird died in a cage, the floor space was reduced by 90 sq in. (580.5 sq cm) by moving a partition to make the compensation. Also, each bird received 5 in. (12 7 cm) of feeding space. When a bird died, cage feeder space was reduced proportionally, so that each of the remaining birds had 5 in. (12.7 cm). The test was repeated four times and the egg production period was 330 days each time. As shown in Table 17.9, only three measurements were statistically significant·

(1) The more birds per cage (the larger the cage), the heavier the body weight at the end of the laying period.
(2) The more birds per cage (the larger the cage), the fewer the percent of soft-shelled eggs.
(3) The more birds per cage (the larger the cage), the greater the percent of broken eggs

Water Consumption in Laying Cages

Invariably laying pullets drink more water when they are on wire than when they are kept on a littered floor This fact, along with more water being drunk during periods of hot weather, may cause difficulties. More moisture is eliminated through the droppings, and they become wet and soggy. In many cage operations the manure becomes difficult to scrape up and remove from the cage building. In pit houses the excess moisture is not easily removed through normal ventilating procedures, the manure must be stirred at regular intervals.

Reducing water consumption Evidently pullets in cages consume more water than they actually need When the droppings are too wet, intermittent watering will eliminate some of the problem, but care should be taken not to reduce water consumption too much during hot weather.

Waterer space Water trough space usually is more than adequate in cages because any trough runs across the entire front area of the cage One cup per cage is adequate, except when cages are exceptionally large and contain a great many birds. Similarly with drip nipples, but remember that one cup will accommodate more birds than one nipple.

Cold Weather Problems

When laying cages are constructed within an insulated and environmentally controlled house, there should be little difficulty during periods of cold weather. But in many mild areas the cages are not enclosed; only a roof protects the birds from the elements. At times wind is more detrimental to good productivity than low temperatures

Wind protection· With open housing, the birds in the outside row of cages are subjected to blowing winds. Some protection should be furnished. Windbreaks should be constructed about 5 to 7 ft (1.5-2.1 m) away from the outside of the house They may be composed of lath fence, lattice, fly screen, or louvers.

Do not let pipes freeze· Before the temperature falls below freezing, all unused pipes and water equipment should be drained.

What to do in Hot Weather

Hot weather may cause extremely high mortality in caged birds They cannot withstand hot climatic conditions as well as birds on a littered floor, caged birds are completely surrounded by hot air, and have no way to get away from the heat Some hot weather helps are

(1) Shade the outside row of cages in open-sided houses

(2) Install foggers with a cleaning device over the birds These foggers may be automatic, that is, they will turn on automatically when the temperature reaches a certain point and turn off at lower temperatures In many instances a pressure system will be needed to make the foggers work efficiently *But be careful* If there is an electric failure at the time of high temperatures, the automatic device that operates the water intake valve to the system or the compressor pump will not work

(3) Sprinkle the roofs of the buildings

(4) Install circulation fans

Artificial Illumination

Some method of maintaining a constant length of light day must be provided Supplemental artificial light will be needed during the season of short hours of natural daylight Light proof houses will need artificial illumination entirely See Chapter 18 for complete details of lighting programs

Light and cannibalism It is a well known fact that the greater the intensity of light, the higher the incidence of cannibalism in laying cages The amount of light necessary to stimulate egg production is much less than many people think Furthermore, when cages are constructed with two or three decks, the upper deck gets the most light, the lower, the least There is no simple solution to this problem The only alternative is to provide the birds in the lower deck with the minimum amount of light, so as not to overilluminate those in the upper deck More picking will be found in the upper deck, where the light is the brightest Cannibalism will be most prevalent in the outside rows in an open sided house, as these rows are exposed to more bright natural daylight Shading the area will be of great help

Egg Handling

Egg collection is either manual or automatic, but which is the better system is highly debatable among poultrymen It is not difficult for an efficient operator to pick up the eggs by hand from 30,000 layers and still have time for other chores To facilitate the procedure, carts are moved through the aisles and the eggs placed in flats on the carts Some carts are motorized, either with electricity or by small gasoline-driven engines But automatic egg-gathering devices are being installed in many new cage operations Eggs roll from the sloping floor of the cage onto a movable belt, which delivers them to a service room at the end of the building Here they are packed in flats

Labor required to gather eggs Figures are highly variable from farm to farm, depending on the efficiency of the procedure On the average it will re

quire about 100 man hours per 1,000 hens per year Automation does not greatly improve this On this basis it would require about 16 minutes of labor per day per 1,000 birds Therefore, one man could gather the eggs from 30,000 birds in an eight hour day

Grading during collection Although it is inefficient to grade eggs according to size at the time of collection, any broken or unusually dirty eggs, or those with poor shells, should be removed as the eggs are gathered The procedure eliminates difficulties later

Cracked eggs Most poultrymen do not realize the seriousness of the number of cracked eggs they get Although most say the percentage is low, recent checks at the grading station showed that in many instances 5% of the eggs received showed cracks During washing and grading more eggs were cracked When 5% of the eggs are cracked through faulty handling by the producer, there would be an annual loss of US$5,000 for every 20,000 hens in production

Some causes of cracked eggs It has been shown that the quality of the eggshell is closely related to the incidence of cracked eggs Some of the influencing factors are

Genetics Some strains of birds have the ability to produce eggs with better shells However, as strains are bred for better egg production, there is a tendency toward a reduction in eggshell quality

Position of egg within a clutch The first eggs of a clutch possess better shell quality than those laid later in the clutch As high producing hens must have longer clutches, the correlation between clutch length and poorer shell quality is obvious

Length of lay The longer the period of egg production, the poorer the shell quality becomes

Temperature The higher the environmental temperature, the poorer the quality of the eggshells When high temperatures occur at the end of the laying period, both factors work to decrease shell quality

Disease Certain respiratory diseases, such as bronchitis and Newcastle disease, have a marked effect on shell quality

Eggshell breaking strength When shell quality is good, it will require from 6 to 8 lb of pressure to break the eggs But when shell quality is poor, 5 lb of pressure will break them, and there is a problem Normally, eggs laid at the end of the laying period will break with 5 lb or less of pressure

How to reduce egg breakage Reducing egg breakage should be a real project on most poultry farms First determine what the present breakage is, then put on a campaign to reduce it Keep a record and plot the progress on graph paper Some methods of reducing the incidence of cracked eggs are

(1) Some strains of egg type layers produce a higher percentage of cracked eggs Make a careful choice

(2) Handle eggs more carefully at the end of the laying period

(3) Start an employee education program to reduce breakage Candle eggs gathered by different personnel, and compare results

(4) Provide a cushion bumper at the front of the egg collection area

(5) Try some cages with fewer birds Crowding increases egg breakage It may be that an excessive number of cracked eggs is cancelling the additional income from more birds per cage
(6) Collect eggs from cages more often Eggs rolling down the floor have a greater chance of creating breakage if there are eggs in the receiving area It is estimated that at least one half of the breakage is due to this
(7) Collect eggs on flats to avoid an extra handling If baskets must be used, do not fill them over half full
(8) Consider changing the ration if poor shell quality is a continuous problem
(9) Reduce every stress possible, stresses lower shell quality in most cases and therefore increase egg breakage
(10) Prevent cannibalism It often causes birds to pick at freshly laid eggs Check on the light intensity
(11) Reduce bird fright The jumping of birds in the cages can only create more cracked eggs
(12) Be sure any automatic egg-gathering equipment does not produce an increase in egg breakage Check the belt material, the speed of the belts, and any angling or corner devices

Oiling Newly Laid Eggs

Most market eggs undergo a washing in specialized equipment before they are cartoned or placed in cases Oiling the newly laid eggs will facilitate the washing procedure A thin mineral oil should be sprayed over the eggs as they are placed on the flats after gathering Another method is to impregnate a sheet of foam rubber with oil and press it against the top of the eggs as they lie on the flats

Dirty Eggs

Egg cleanliness is one reason for the rapid acceptance of laying cages However, there will be times when eggs seem to get dirty, even with cages Humidity and dust will collect on cage floors at times, and as the eggs roll down the wire dirty rings will be left on the shells Try to eliminate all dust possible Do not allow the cage wires to rust Some wire floors are constructed of material that is rust resistant Keep automatic egg gathering belts clean One broken egg can dirty several clean ones

Egg Cooling Room

Each cage laying farm must be provided with an egg-cooling room If the poultry houses are large it is best to construct such a room in each house See Chapter 12

Age of Pullet at First Egg

Annual average egg weight is correlated with the age of the pullet when she lays her first eggs Since age at first eggs may be controlled by lighting programs and increasing or decreasing the feed intake, the management program must be one that gets the bird to sexual maturity at the most opportune age Although the egg-size relationship is indirect, that is, eggs are larger because the bird is older at the time she goes through her laying cycle the relationship is important But forcing pullets to delay the onset of egg production increases the cost of raising a

pullet, which of course raises the cost of producing a dozen eggs. Thus, the poultry manager must weigh the added pullet costs against the greater cash return from larger eggs. The most economical age for first eggs is during the 20th or 21st week, with the flock attaining 5% egg production on a hen-day basis during the 22nd or 23rd week of age. At about 25 to 27 days after the first egg is produced the flock should attain 50% egg production on a hen-day basis.

Economic Importance of Mortality

Excessive mortality during the laying period is an expensive management failure. Not only is there a loss of the bird herself, but the profit she would have generated does not materialize. There probably is no such thing as "normal" mortality; thus there is no method of determining "excessive" mortality. Studies of large cage laying farms in southern California have shown that monthly average death losses have been from 1.5 to over 2%. However, individual farms have had losses as low as 0.5% per month. Some strains of layers have a lower incidence of mortality than others, so all excessive mortality cannot be the result of poor management. Yet one should certainly feel that anything over 1% per month is attributable to management.

Much of the variation in cage mortality in the past has been due to Marek's disease, for which there was no control or treatment. But with the advent of a vaccine for this disease, there should be fewer fluctuations because of heavy death loss from this cause. This discovery and the use of the vaccine should now place remaining "excessive" mortality in the hands of the poultryman.

Fallacy of "hen-day" egg production: Poultry managers who have birds in laying cages have become accustomed to measuring the egg productivity of their flock on the basis of "hen-day" egg production. Although it is a precise index of how well the remaining live birds are producing eggs, it makes egg production look better than it really is because it does not consider mortality. "Hen-housed" egg production is a better figure from an economic standpoint, as it is an index of the productivity of the original birds housed. However, "hen-housed" egg production is a measure of both mortality and egg production, and therefore it has its fallacies too.

Relationship Between Production Indexes

Some indication of the variations occurring with different methods of measuring flock egg productivity are given below. The only assumption involved in constructing the data is that flock mortality was uniform throughout the year (365 days) at 1.25% per month.

Eggs produced per hen per year, *hen-housed*	240
Percent egg production per hen per year, *hen-housed*	65.8
Eggs produced per hen per year, *hen-day*	259.5
Percent egg production per hen per year, *hen-day*	71.1

Culling During Production

Crippled, picked, and birds with blowouts should be removed from the laying cages at regular intervals. Many will be uneconomical to keep; they only add to the expense of maintaining the profitable birds. But under normal circumstances, do not try to cull the poorer egg producers; it is an uneconomical practice.

Replacement Schedule

There are two periods involved with the replacement schedule

(1) Replacements during the egg production period

Common several years ago was the procedure of replacing culled or dead pullets with new and younger birds The practice is not profit able, because the new pullets are not in egg production long enough to complete a full laying year, and because they often do not adjust to the cage social order of older birds in the cage Do not replace culled or dead birds

(2) Replacements at the end of the laying cycle

It is better to practice the "all in, all out" system of management on cage farms where all the layers in the cage operation are the same age, complete their laying year at the same time, and all can be removed from the farm during a brief period But sometimes this is not practical, and *lines* of cages will need new pullets during different months of the year Proper scheduling of the replacements will be necessary to avoid excessive downtime

FEEDING CAGED LAYERS

Although the nutrition of caged layers is detailed in later chapters, some feed management problems are best discussed here

Type of Feeding Program

Prior to the time the pullets reach sexual maturity it will be necessary to deter mine the form of feed mash, crumbles, or pellets If phase feeding is to be used, a complete understanding of the principles involved with this procedure must be studied The incorporation of any medicaments in the laying feed must be considered

How to Feed

To induce greater consumption of feed, there should be at least two feedings per day when the feed is administered by hand In addition, the feed should be stirred once or twice a day This is accomplished by running a paddle down the feed trough One paddle in each hand will stir the feed in troughs on opposite sides of the aisle

Prevent feed wastage Feed beaked out of a feed trough is a complete waste, there is no way the birds can get to it A study of the amount of feed wastage when layers were kept in cages was made at Oregon State College The findings showed that the more pullets there were in a cage, the less the feed loss Seemingly, more birds at the trough allows less space for picking and billing the feed Lower light intensity will also reduce feed wastage Do not put much feed in the troughs at one time, provide fresh feed oftener The results of the Oregon test were as follows

Number of birds per cage	Feed wasted per bird per year	
	Lb	Kg
1	4 52	2 05
2	2 01	91
3	1 08	49

Changing to the Laying Ration

When the flock lays its first eggs, a laying feed should be substituted for the growing ration. If the form of feed is not involved, and the growing birds have been full-fed, the change can be made in one day. However, when the growing pullets have been on a program of feed restriction, the changeover should be gradual. Increase the feed allowance 1 lb (454 gm) per 100 pullets per day until they are on full feed. Continue to full-feed until the pullets are past their peak of egg production. At that time a decision must be made as to whether full-feeding is to continue or some method of feed control is to be followed.

Caution Always full-feed (self-feed) from near the start of egg production until after the peak of egg production. This is a period of high nutritive demand; egg production and body weight increase rapidly

Maintaining Body Weight During Laying

Caged layers must gain weight during their production year. As caging is conducive to heavier body weights than when pullets are kept on the floor, there is usually no problem in maintaining the proper weight increase when the weather is cool or normal. However, during periods of hot weather, birds do not consume as much feed, and there is always the possibility that body weight will suffer. Lowering the environmental temperature, giving fresh feed early in the morning and later in the afternoon to increase feed consumption during the cool hours of the day, along with plenty of cool, fresh water will be of help

If there is a problem with excessive body weight, it may be best to initiate some form of feed control during the laying cycle

Record daily feed consumption Always know how much feed is being consumed, keep a daily record To correlate this information with body weight, weigh approximately 10% of the birds in each line of cages every four weeks. Pullets should be weighed at the same hour of the day each time, preferably in the late afternoon

Feeding Grit to Caged Layers

There is recent experimental evidence to support the recommendation for feeding grit to caged layers. Some reports show that egg production is improved, but the amount of grit necessary is small.

How much grit to feed Feed 0 5 lb (227 gm) of hen-size grit per 100 laying pullets in cages per week. With automatic feeders it is better to feed 2 lb (908 gm) per 100 pullets every 4 weeks. Otherwise the first birds on the automatic feed line may get most of the grit.

Caution· Do not feed more grit than recommended, and never self-feed

LAYING CAGE DISEASES

Because of close confinement, certain respiratory diseases are quite common in laying birds housed in cages. Coryza is an important one, as there is no fool-proof method of control. Bronchitis and Newcastle disease are two others, but usually these may be kept under control through a good program of vaccination

Cage layer fatigue· Birds kept in cages develop brittle bones, the height of the incidence being determined by several factors. Such layers have difficulty in standing, but egg production does not seem to be greatly affected.

However, the market value of the spent hens will be seriously reduced, often to the point that the birds cannot be sold. There is no known control measure.

Fatty liver syndrome: Caged layers are prone to increased fat deposition, sometimes to the extent that the liver is affected. The condition is known as fatty liver syndrome. There are some remedial measures, but at times nothing seems of value.

Further discussion: See Chapter 41 for a more detailed discussion of the diseases mentioned above.

CAGE INSECT CONTROL

Flies are the common difficulty encountered with most cage operations. Successful fly control programs are built around keeping fly breeding to a minimum and the use of approved insecticides. Some suggestions are:

(1) Keep large doors of the house closed.

(2) Prevent accumulation of organic material such as waste, broken eggs, and other debris.

(3) Control moisture. Flies do not readily breed in material containing less than 50% moisture. Repair water leaks, overflowing waterers, and drains

(4) Manage manure accumulation. Keep the manure as dry as possible by stirring or forcing air over it. If practical, remove the manure often, except in pits

(5) Start the fly-control program early. Keep the fly population at a low level.

Insecticides for practical use. Refer to Chapter 42 for a list of approved insecticides *Remember* that some insecticides have a residual effect in poultry meat and eggs and cannot be legally used on poultry farms.

MANURE DISPOSAL

The handling of manure on a cage poultry farm requires management techniques of enormous proportions. Many methods have been tried. House design is an important factor. Not only is the moisture content of poultry manure a problem, but the fly aggravation associated with poultry droppings may take on major proportions.

Wet droppings High dietary levels of protein and high levels of salt in the ration are instrumental in increasing the amount of moisture in the droppings As environmental temperatures rise, the pullets drink more water, thereby increasing fecal moisture Certain stresses will increase the incidence of wet droppings. It is under such conditions that the cause must be eliminated

Droppings odor Fumes from the ammonia in the droppings plus those created by bacterial action are obnoxious The odors are accentuated when droppings are wet Some odors may be materially reduced by using some commercial products on the market. Regular removal of the manure below cage floors should be made a part of the management program. Stir the manure in pits, exposure to the air will help dry the droppings

Manure accumulation in the deep pithouse Although highly variable, about 12 in (30.5 cm) of droppings will accumulate in deep pits under cages per year

Manure disposal There are many mechanical, chemical, and bacterial methods of manure disposal that are practical on poultry farms These are discussed in Chapter 44

MARKET EGG QUALITY

Egg quality is a composite of those factors necessary for the egg to be acceptable to the consumer Although the egg is laid with its maximum quality, there is also the interest in maintaining this degree of perfection Most of the factors associated with quality are measurable The most important are as follows

Egg Size

Most eggs are sold by the dozen or by weight Even when the dozen is the standard unit, eggs are graded so that dozens will vary in weight Thus, egg weight becomes an important criterion of a hen's ability to produce at a profit, for larger eggs return more money to the producer than smaller eggs There are several factors that affect the weight of the eggs a hen produces

Strain of birds Egg size is a genetic factor, thus it is possible to develop strains of chickens laying large, medium, or small eggs

Age at first egg The older a pullet is when she lays her first egg, the larger her eggs during her laying period Inasmuch as it is possible to delay the onset of egg production, the age association becomes an important economic consideration

Environmental temperature *As ambient temperatures rise, egg size de*creases At times hot weather will create a major egg size problem

Egg size when birds kept in cages Normally, and under similar circumstances, pullets in cages produce eggs that are slightly larger than those laid by pullets kept on a littered floor

Laying ration Certain components of the laying ration will affect egg size Increases in protein percentage usually are associated with increases in egg size

Size of pullets in the flock The larger the pullet *within a given flock*, the larger the eggs As the larger birds also produce more eggs, body weight becomes important However, the birds in a flock are never uniform in weight They go from small to medium to large Thus, there is little that can be done to control this *normal* variation

Egg size variation throughout the laying period The first eggs a pullet lays are the smallest Gradually, egg size increases as the hen progresses into her laying period Many factors influence this increase in egg weight, many have been studied But strains of chickens vary according to their genetic makeup, so it is difficult to produce any type of table that would be indicative of all strains Rather than give actual weights, Table 17 10 is presented to show the variations by four week periods as a percent of the average annual egg weight Even then, this table would vary under circumstances involved with different temperatures, hatching period, strain, and management

TABLE 17 10

PERIOD VARIATIONS IN EGG WEIGHT EXPRESSED AS PERCENT OF ANNUAL AVERAGE

Weeks of Egg Production	Average Egg Weight for Period Expressed as Percent of Annual Average
1 through 4	83 8
5 through 8	89 0
9 through 12	94 5
13 through 16	96 9
17 through 20	98 4
21 through 24	100 4
25 through 28	101 6
29 through 32	102 8
33 through 36	103 6
37 through 40	104 3
41 through 44	105 0
45 through 48	105 7
49 through 52	106 3

Measurements of Egg Quality

Even fresh eggs vary in many ways Shell strength, condition of the albumen, yolk color, and incidence of blood and meat spots differ These, along with other quality factors, deteriorate as the eggs age

Specific gravity of eggs Specific gravity of an agg and shell thickness are related higher specific gravities are indicative of greater shell thickness An egg is placed in solutions of different specific gravities until the solution is found where the egg floats The specific gravity of each solution is given a score and these figures are those commonly used They are

Specific gravity Solution	Score
1 068	0 (thinnest shell)
1 072	1
1 076	2
1 080	3
1 084	4
1 088	5
1 092	6
1 096	7
1 100	8 (thickest shell)

Any specific gravity score above 4 indicates good eggshell quality, but annual averages of all eggs laid may vary between 3 0 and 5 0, showing that shell quality as exemplified by shell thickness is an inherited factor

Haugh units to measure albumen quality Freshly laid eggs show a great variation in their albumen quality when measured by its ability to remain viscous The age of the eggs also influences the quality of egg albumen

Haugh units are based on measurement of the height of the albumen in relation to the weight of the egg A complicated formula is used to work

out the indexes, but there are recording devices that do this automatically. The range index falls between 100 (best) and 30 (poorest). The U.S. Department of Agriculture, in classifying eggs according to quality, states that to be Grade AA, the Haugh unit index must be above 72. As albumen quality deteriorates during hot weather and during the latter part of the laying period, it will be necessary to maintain an annual average of all eggs laid of at least 78 if the score is to remain above 72 at all times.

USDA egg grades and Haugh units: The figures for USDA egg grades are:

USDA grades	Haugh units
AA	72 and over
A	60 to 72
B	31 to 60

Air cell and egg quality: Normally the two shell membranes are separated at the large end of the egg to form the air cell. In the newly laid egg this cell is approximately 3/4 in. (1.9 cm) in diameter and 1/8 in. (0.32 cm) in depth. As the egg ages the diameter and depth of the air cell increase, the speed depending on temperature and composition of the gases surrounding the egg. In the United States, eggs are suitable for human consumption provided the air cell is no more than 3/8 in. (0.96 cm) in depth.

Blood spots in eggs: Blood spots are classified according to their size. Small blood spots are less than 1/8 in. (0.32 cm) in diameter; large ones are greater than this. Leghorn strains vary in the number of eggs they lay with blood spots; usually the quantity is between 0.6 and 2.0%. Eggs from brown-egg layers will usually show a higher incidence of blood spots than those from white-egg strains.

Meat spots in eggs: Meat spots are grouped according to their size. Large ones are 1/8 in. (0.32 cm) or more in diameter; small ones are less than 1/8 in. The number of meat spots is much less than the number of blood spots.

Yolk shadow: When an egg is candled the yolk creates a definite shadow. It is more pronounced in eggs with white shells than in those with brown shells. In fresh eggs the shadow is light, as the thick albumen tends to keep the yolk centralized within the shell. But as the egg ages, the albumen becomes thinner, allowing the yolk to approach the shell, and thereby creating a darker shadow. The intensity of the yolk shadow is an indication of the quality (age) of an egg.

Yolk color: The density of the yellow pigment in egg yolks is closely related to the pigmenting chemicals in the ration. The yolk-color variations may be classified according to a color indicator.

Consumers vary in their choice of yolk-color density; some prefer light-colored yolks, some prefer dark. In most cases the diet is altered so as to produce egg yolks of the correct color density. Many eggs find their way to egg-breaking plants where the yolks and whites are separated and either dried or frozen, later to be used in food preparation. As many yolks are used for the production of noodles and similar products, there is a necessity for an intense yellow color. In many instances yolk-color intensifiers are added to the feed.

Contract Egg Production

The production of market eggs on a contract basis has gained an important foothold in the industry during the past few years as the result of an increased amount of integration Under such contracts, the PRODUCER furnishes the buildings, equipment, labor and a few incidentals, while the INTEGRATOR furnishes the pullets, feed, and some other items, along with the necessary supervision

Contract PRODUCER return There are many methods for paying the PRODUCER for the use of his equipment and for his services These too, are variable One common and simple method is for the INTEGRATOR to pay the PRODUCER a contracted price based on each dozen eggs produced and delivered to the INTEGRATOR Because of the low market value for small eggs, the contract price for small eggs is often lower than for larger ones One common contract calls for the following payments

Small eggs (peewees)	US$ 04 per dozen
Other eggs	US$ 05 per dozen

A contract of this type offers the incentive for the PRODUCER to do a good job, the more eggs he produces, the greater his cash return

COST MANAGEMENT IN CAGES

Producing market eggs at a profit is the end point of a complex program, not only through good flock behavior, but in the poultryman's ability to manage his egg production costs These costs are best itemized as those necessary to produce one dozen eggs

Cost of Producing One Dozen Eggs

Although not always an accurate method of evaluating cost efficiency, because it does not consider egg size and egg quality, the index of "cost of producing a dozen eggs" is one common to the poultry industry The estimated costs are given in Table 7.11 for pullets laying 20 dozen (240) eggs in 52 weeks on a *hen housed basis* Obviously, the costs in the table are representative of a good, efficient oper

TABLE 17 11

ESTIMATED CAGE COSTS OF PRODUCING ONE DOZEN MARKET EGGS
(20 dozen eggs per hen housed)
(In U.S dollars)

Item	Leghorn	Medium-size(1)
Pullet growing cost	$0 070(2)	$0 083(3)
Feed	150(4)	.158(5)
Labor	010	010
Housing	007	008
Equipment	012	013
Other costs	025	025
(Less) Hen salvage value	(010)	(015)
Total	$0 264	$0 282

(1) Producing brown-shelled eggs.
(2) $1 40 per pullet amortized over 20 dozen eggs.
(3) $1.65 per pullet amortized over 20 dozen eggs.
(4) 4 lb (1.81 kg) per dozen eggs @ $.0375/lb ($.082/kg)
(5) 4.2 lb (1.91 kg) per dozen eggs @ $.0375/lb ($.082/kg)

ation However, egg production costs are often lower, more often, they are higher Feed cost may be a determining factor But in this day of narrow margins of profit from egg production it will be necessary to keep costs somewhere near those given in the table

Feed Cost Per Dozen Eggs

About 57% of the cost of producing 1 dozen market eggs is feed cost It is the largest of the cost items, and consequently represents an important facet for an egg cost analysis Two items go into a calculation of the cost of feed per dozen eggs

(1) Pounds (kg) of feed necessary to produce one dozen eggs

(2) Cost of feed per lb (kg)

In order to show the relationship between the above two variables, Table 17 12 is given

Reducing feed cost per dozen eggs The answer to methods of reducing feed cost does not lie entirely with the price of feed There are many ways of reducing feed cost per egg unit other than obtaining cheaper feed Some of these methods are as follows

(1) *Reduce the pullet body weight* Pullets reaching sexual maturity at a reduced size will usually remain smaller during the laying period, thus requiring less feed

(2) *Increase egg production* When egg production increases, the amount of feed necessary to produce a dozen eggs decreases There are many management factors that increase egg production

(3) *Use controlled feeding during laying period* Maintaining correct body weight during the laying period through controlled feeding will keep the pullets from getting overly heavy and consuming more feed than normal

(4) *Use phase feeding* The main purpose behind phase feeding is to lower the cost of the feed consumed by a pullet during her laying period

(5) *Follow a rigid culling program* Culls consume feed which must be charged to egg production

(6) *Prevent feed wastage* When as little as 0 5 lb (227 gm) of feed is wasted per pullet per year, the cost of producing eggs is increased by about US$0 001 per dozen

Pullet Growing Cost Per Dozen Eggs

The cost to grow the pullet is a necessary factor in determining the cost to produce a dozen eggs As is the second largest of the expense items, it is of great importance Table 17 13 shows the relationship between pullet costs and egg production costs

Age at first egg Pullet growing costs are closely related to the age at which first eggs are produced The longer a bird is kept out of egg production, the longer the growing period and the greater the costs However, this factor is not responsible for all variations in this item Efficiency, ability to grow a high percentage of the chicks that are started, freedom from flock disease, and other costs enter into the final figure

As the age of sexual maturity is delayed, egg size increases, particularly for those eggs produced at the beginning of the laying cycle However, the

TABLE 17 12

CALCULATING FEED COST PER DOZEN EGGS
(In U S Cents per Dozen Eggs)

Feed per Dozen Eggs		Feed Cost per Pound, in Cents															
		3 0	3 1	3 2	3 3	3 4	3 5	3 6	3 7	3 8	3 9	4 0	4 1	4 2	4 3	4 4	4 5
		Feed Cost per Kilo, in Cents															
Lb	Kg	6 6	6 8	7 0	7 3	7 5	7 7	7 9	8 1	8 4	8 6	8 8	9 0	9 2	9 5	9 7	9 9
3 1	1 41	9 3	9 6	9 9	10 2	10 5	10 9	11 2	11 5	11 8	12 1	12 4	12 7	13 0	13 3	13 6	14 0
3 2	1 45	9 6	9 9	10 2	10 6	10 9	11 2	11 5	11 8	12 2	12 5	12 8	13 1	13 4	13 8	14 1	14 4
3 3	1 50	9 9	10 2	10 6	10 8	11 2	11 6	11 9	12 2	12 5	12 9	13 2	13 5	13 9	14 2	14 5	14 9
3 4	1 54	10 2	10 5	10 9	11 2	11 6	11 9	12 2	12 6	12 9	13 3	13 6	13 9	14 3	14 6	15 0	15 3
3 5	1 59	10 5	10 9	11 2	11 6	11 9	12 2	12 6	13 0	13 3	13 7	14 0	14 4	14 7	15 1	15 4	15 8
3 6	1 63	10 8	11 2	11 5	11 9	12 2	12 6	13 0	13 3	13 7	14 0	14 4	14 8	15 1	15 5	15 8	16 2
3 7	1 68	11 1	11 5	11 8	12 2	12 6	13 0	13 3	13 7	14 1	14 4	14 8	15 2	15 5	15 9	16 3	16 7
3 8	1 72	11 4	11 8	12 2	12 5	12 9	13 3	13 7	14 1	14 4	14 8	15 2	15 6	16 0	16 3	16 7	17 1
3 9	1 77	11 7	12 1	12 5	12 9	13 3	13 7	14 0	14 4	14 8	15 2	15 6	16 0	16 4	16 8	17 2	17 6
4 0	1 81	12 0	12 4	12 8	13 2	13 6	14 0	14 4	14 8	15 2	15 6	16 0	16 4	16 8	17 2	17 6	18 0
4 1	1 86	12 3	12 7	13 1	13 5	13 9	14 4	14 8	15 2	15 6	16 0	16 4	16 8	17 2	17 6	18 0	18 5
4 2	1 91	12 6	13 0	13 4	13 9	14 3	14 7	15 1	15 5	16 0	16 4	16 8	17 2	17 6	18 1	18 5	18 9
4 3	1 95	12 9	13 3	13 8	14 2	14 6	15 1	15 5	15 9	16 3	16 8	17 2	17 6	18 1	18 5	18 9	19 4
4 4	2 00	13 2	13 6	14 1	14 5	15 0	15 4	15 8	16 3	16 7	17 2	17 6	18 0	18 5	18 9	19 4	19 8
4 5	2 04	13 5	14 0	14 4	14 9	15 3	15 8	16 2	16 7	17 1	17 6	18 0	18 5	18 9	19 4	19 8	20 3
4 6	2 09	13 8	14 3	14 7	15 2	15 6	16 1	16 6	17 0	17 5	17 9	18 4	18 9	19 3	19 8	20 2	20 7
4 7	2 13	14 1	14 6	15 0	15 5	16 0	16 5	16 9	17 4	17 9	18 3	18 8	19 3	19 7	20 2	20 7	21 2
4 8	2 18	14 4	14 9	15 4	15 8	16 3	16 8	17 3	17 8	18 2	18 7	19 2	19 7	20 2	20 6	21 1	21 6
4 9	2 22	14 7	15 2	15 7	16 2	16 7	17 2	17 6	18 1	18 6	19 1	19 6	20 1	20 6	21 1	21 6	22 1
5 0	2 27	15 0	15 5	16 0	16 5	17 0	17 5	18 0	18 5	19 0	19 5	20 0	20 5	21 0	21 5	22 0	22 5

TABLE 17 13

PULLET COST AS IT AFFECTS PULLET COST PER ONE DOZEN EGGS
(in U S cents)

Pullet Growing Cost	Number of Eggs Produced per Pullet per Year					
	204	216	228	240	252	264
	Number of Dozens Eggs per Pullet per Year					
	17	18	19	20	21	22
	Pullet Cost per Dozen Eggs					
US $1 10	6 5	6 1	5 8	5 5	5 2	5 0
1 20	7 1	6 7	6 3	6 0	5 7	5 5
1 30	7 7	7 2	6 8	6 5	6 2	5 9
1 40	8 2	7 8	7 4	7 0	6 7	6 4
1 50	8 8	8 3	7 9	7 5	7 1	6 8
1 60	9 4	8 9	8 4	8 0	7 6	7 3
1 70	10 0	9 4	9 0	8 5	8 1	7 7
1 80	10 6	10 0	9 5	9 0	8 6	8 2
1 90	11 2	10 6	10 0	9 5	9 1	8 6
2 00	11 7	11 1	10 5	10 0	9 5	9 1
2 10	12 4	11 7	11 1	10 5	10 0	9 6
2 20	12 9	12 2	11 6	11 0	10 5	10 0

extra value of the larger eggs must be balanced against the added cost of keeping the pullet longer in the growing period In most instances egg production should reach 5% on a hen-day basis when the pullets are 22 to 23 weeks of age When egg production starts earlier or later the cost per egg unit increases

Other Cost Items

There are many items other than feed and pullet cost that go into cost of pro ducing eggs Although these should be studied continually in an endeavor to make a reduction in their appropriate cost, many times it is useless to try to economize by spending time on them Investment and some overhead items are fixed costs and usually cannot be reduced

Mortality as a cost item Many cage laying operations show a mortality rate of less than 0 5% per month, others may show over 2% Certainly, some percentage is "normal," but "excessive" death losses are the result of poor management Although mortality is not a direct cost of producing eggs, it is certainly an indirect cost, and at times may become a major cost item Most "excessive" mortality could be reduced or eliminated on a good pro portion of cage layer farms

Records

An adequate record of the behavior of the caged layers must be kept It should contain items such as egg production, egg size, feed consumption, mortality, body weight, egg quality, and medications In addition to these production records, facts associated with cost management must be recorded, for the ability of the poultryman to produce eggs at the lowest possible cost is the ultimate of attaining the highest profit Examples of these records and other pertinent information are given in Chapter 21

TABLE 17.12

CALCULATING FEED COST PER DOZEN EGGS
(In U.S. Cents per Dozen Eggs)

Feed per Dozen Eggs		Feed Cost per Pound, in Cents															
		3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5
		Feed Cost per Kilo, in Cents															
Lb	Kg	6.6	6.8	7.0	7.3	7.5	7.7	7.9	8.1	8.4	8.6	8.8	9.0	9.2	9.5	9.7	9.9
3.1	1.41	9.3	9.6	9.9	10.2	10.5	10.9	11.2	11.5	11.8	12.1	12.4	12.7	13.0	13.3	13.6	14.0
3.2	1.45	9.6	9.9	10.2	10.6	10.9	11.2	11.5	11.8	12.2	12.5	12.8	13.1	13.4	13.8	14.1	14.4
3.3	1.50	9.9	10.2	10.6	10.8	11.2	11.6	11.9	12.2	12.5	12.9	13.2	13.5	13.9	14.2	14.5	14.9
3.4	1.54	10.2	10.5	10.9	11.2	11.6	11.9	12.2	12.6	12.9	13.3	13.6	13.9	14.3	14.6	15.0	15.3
3.5	1.59	10.5	10.9	11.2	11.6	11.9	12.2	12.6	13.0	13.3	13.7	14.0	14.4	14.7	15.1	15.4	15.8
3.6	1.63	10.8	11.2	11.5	11.9	12.2	12.6	13.0	13.3	13.7	14.0	14.4	14.8	15.1	15.5	15.8	16.2
3.7	1.68	11.1	11.5	11.8	12.2	12.6	13.0	13.3	13.7	14.1	14.4	14.8	15.2	15.5	15.9	16.3	16.7
3.8	1.72	11.4	11.8	12.2	12.5	12.9	13.3	13.7	14.1	14.4	14.8	15.2	15.6	16.0	16.3	16.7	17.1
3.9	1.77	11.7	12.1	12.5	12.9	13.3	13.7	14.0	14.4	14.8	15.2	15.6	16.0	16.4	16.8	17.2	17.6
4.0	1.81	12.0	12.4	12.8	13.2	13.6	14.0	14.4	14.8	15.2	15.6	16.0	16.4	16.8	17.2	17.6	18.0
4.1	1.86	12.3	12.7	13.1	13.5	13.9	14.4	14.8	15.2	15.6	16.0	16.4	16.8	17.2	17.6	18.0	18.5
4.2	1.91	12.6	13.0	13.4	13.9	14.3	14.7	15.1	15.5	16.0	16.4	16.8	17.2	17.6	18.1	18.5	18.9
4.3	1.95	12.9	13.3	13.8	14.2	14.6	15.1	15.5	15.9	16.3	16.8	17.2	17.6	18.1	18.5	18.9	19.4
4.4	2.00	13.2	13.6	14.1	14.5	15.0	15.4	15.8	16.3	16.7	17.2	17.6	18.0	18.5	18.9	19.4	19.8
4.5	2.04	13.5	14.0	14.4	14.9	15.3	15.8	16.2	16.7	17.1	17.6	18.0	18.5	18.9	19.4	19.8	20.3
4.6	2.09	13.8	14.3	14.7	15.2	15.6	16.1	16.6	17.0	17.5	17.9	18.4	18.9	19.3	19.8	20.2	20.7
4.7	2.13	14.1	14.6	15.0	15.5	16.0	16.5	16.9	17.4	17.9	18.3	18.8	19.3	19.7	20.2	20.7	21.2
4.8	2.18	14.4	14.9	15.4	15.8	16.3	16.8	17.3	17.8	18.2	18.7	19.2	19.7	20.2	20.6	21.1	21.6
4.9	2.22	14.7	15.2	15.7	16.2	16.7	17.2	17.6	18.1	18.6	19.1	19.6	20.1	20.6	21.1	21.6	22.1
5.0	2.27	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	20.5	21.0	21.5	22.0	22.5

Candela: The word is derived from "candle." A candela is the unit of luminous intensity of a light source in a specified direction.

Lumen: The lumen is defined as the rate at which light falls on a square foot area surface which is equally distant 1 ft from a source whose intensity is 1 candela. A lumen is a standard of measurement of the light intensity from electric bulbs of various types and sizes.

Lux: A lux of light intensity is equal to one lumen per square meter, and the term is regularly used in some countries. One lux is equal to 0.0929 footcandle. One footcandle equals 10.76 lux.

Lumen efficiency: The amount of electricity necessary to light a bulb is measured in *watts*. The number of lumens of light per watt of bulb is an indicator of the efficiency of the light source. With incandescent bulbs, the rule of thumb is that 1 watt produces 12.56 lumens of light. However, the figure varies with the size of the bulb; small bulbs produce more lumens, larger produce less. With fluorescent lamps, the efficiency is much greater.

Footcandles: Illumination on a surface is measured in footcandles. A footcandle is defined as the density of light striking each and every point on a segment of the inside surface of an imaginary one-foot radius sphere with a one candlepower source at the center. Thus, 1 footcandle equals 1 lumen per square foot.

Available lumens (light): All light generated by a light bulb is not available to the chicken. Many of the rays of an open bulb without a reflector reach the bird only after reflecting off some surface or object. About 30% of the lumens are absorbed by the walls, ceiling, equipment, etc. Deterioration and cloudiness of the bulb reduce the light given off by about 30%. Therefore, only about 49% of the rated lumens are available to the chicken.

Example: One watt equals 12.56 lumens; 49% of 12.56 lumens equals 6.15 lumens per watt, the amount available.

Calculating footcandles: One 60-watt incandescent bulb produces 753.6 lumens of light (60 × 12.56), but only 369.3 lumens of usable light (753.6 × 49%). If spread over 240 sq ft of surface there would be 1.54 footcandles per square foot. Although this is a mathematical conception of light intensity, in the chicken house the distance from the light source to the area at the location of the birds affects the intensity.

Comparison of Incandescent and Fluorescent Bulbs

The illuminating power of white incandescent and white fluorescent bulbs when compared on a per-watt basis varies greatly, as can be seen in Table 18.1. However, peak efficiency of fluorescent bulbs can be maintained only when the temperature of the surrounding air is between 70° and 80°F (21.1° to 26.7°C) unless the fixtures are enclosed. Efficiency is reduced with temperatures above or below this optimum. At 30° to 40°F (-1.1° to 4.4°C), for example, only about 60% of the maximum output is produced.

Recommendation: In most instances, fluorescent lights are unsatisfactory for poultry house lighting. If they must be used, the wattage of the bulbs should equal the recommendations for incandescent lighting.

Lighting Management

It is a well known fact that light intensity and the length of the daily light period produce responses associated with egg production The responses are the result of increased activity of the anterior lobe of the pituitary gland located at the base of the brain Light *stimulation causes the release of the* follicle stimulating hormone (FSH) from the pituitary, which in turn causes an increase in the growth of the ovarian follicles Upon reaching maturity, the ovum is re leased by the action of another hormonal secretion from the pituitary, the leutein izing hormone (LH)

It may be seen therefore, that the initiation of egg production and the ability to produce a larger number of eggs during the laying period are greatly affected by the stimulus of light to activate the pituitary Under normal conditions, sunlight produces the effect, but in commercial poultry production artificial light is used to supplement the hours of natural daylight The cumulative effects of both are instrumental in causing changes in the age at which pullets begin to lay and in the number of eggs produced

SOME FACTS ABOUT LIGHT

Natural daylight is supplied by the sun The intensity of the sun's light rays has a day by-day variation as the result of the position of the sun, cloudiness, dust and moisture in the air, and other factors However, the length of the light day varies too The relative position of the earth to the sun causes differences in the length of the daily daylight period In the Northern Hemisphere, June 21st is the longest day of the year, December 21st, the shortest In the Southern Hemisphere, the dates are reversed Because the earth's surface is curved, daylight occurs from 15 to 30 minutes before sunrise and darkness occurs 15 to 30 minutes after sunset Thus, the length of the light day is somewhat longer than the hours between sun rise and sunset, but the time between sunrise and sunset is usually considered the light day

Light Vision

As seen by the human eye, light is only that part of the radiant energy spectrum that is represented by wavelengths between about 400 and 700 millimicrons The limits of the chicken eye are quite similar to those of the human eye All chickens have color vision There is some indication that they are able to see better when illumination is by those rays at the long end of the spectrum, such as red, orange, yellow, and perhaps green The quantity of light necessary for chickens to see to eat is unusually low After some training, birds will find their way to the feeders and eat when the light intensity is less than one fourth footcandle However, it requires from two to four times this amount of light to stimulate the pituitary and increase egg production

Measuring Light

Light has various measurements, most of which are very specific Those used in the course of poultry management are

Height of bulbs: Light bulbs should be placed as close to the bird area as is practical. So that the attendant may walk under them, this usually is about 7 to 8 ft (2.1-2.4 m) in houses with a littered floor or in cage houses with a service aisle. Avoid hanging bulbs by a cord in open houses. The wind whips them around causing shadows across the birds, often frightening them. Table 18.2 shows the height and size of light bulbs to produce 0.5 and 1 footcandle at bird level.

TABLE 18.2

INCANDESCENT LAMP SIZE AND HEIGHT TO PRODUCE ONE-HALF AND ONE FOOTCANDLE AT BIRD LEVEL

	Height of Lamps above Bird Level							
	To Produce 1/2 Footcandle at Bird Level				To Produce 1 Footcandle at Bird Level			
Lamp Size Watts	With Reflectors Ft	With Reflectors M	Without Reflectors Ft	Without Reflectors M	With Reflectors Ft	With Reflectors M	Without Reflectors Ft	Without Reflectors M
15	5	1.5	3.5	1.1	3.5	1.1	2.5	0.7
25	6.5	2.0	4.5	1.4	4.5	1.4	3	0.9
40	9	2.7	6.5	2.0	6.5	2.0	4.5	1.4
60	14	4.3	10	3.1	10	3.1	7	2.1
75	15.5	4.7	10.5	3.2	10.5	3.2	7.5	2.3
100	19	5.8	13.5	4.1	13.5	4.1	9.5	2.9

Size of bulbs: The usual recommendation is to supply 1 bulb watt for each 4 sq ft (0.37 sq m) of floor space to provide 1 footcandle of light. This is approximate when the bulbs are under a good reflector and 7 to 8 ft above the floor. Arrange the height and distribution of the bulbs so that is is not necessary to use larger than 60-watt bulbs. When larger bulbs are to be used, the light distribution is less uniform and it requires more electricity to operate the bulbs.

Dirty Bulbs

Very dusty bulbs will emit about one-third less light than clean bulbs. Note the following equivalent light intensities:

Type of bulb	Equivalent light intensity
Clean bulb, clean reflector	60-watt bulb
Clean bulb, no reflector	40-watt bulb
Dirty bulb, dirty reflector	40-watt bulb
Dirty bulb, no reflector	25-watt bulb

Light bulbs should be cleaned every two weeks under normal circumstances; oftener if necessary. Also, replace burned-out bulbs each day. This recommendation is particularly true for birds in cages, because the birds cannot move about to find other areas that are lighted.

Color of Light

The color of the light rays has an effect on the productivity of chickens. A part of this difference is thought to be due to the fact that the oil droplets in the retina

TABLE 18 1

LUMENS OF LIGHT FROM WHITE INCANDESCENT AND FLUORESCENT BULBS

Bulb Watts	Incandescent Bulbs Lumens	Fluorescent Bulbs Lumens
15	125	500-700
25	225	800-1,000
40	430	2,000-2,500
50	655	
60	810	
75		4,000-5 000
100	1,600	
150	2 500	
200	3,500	10,000-12,000

Placement of Light Bulbs

The manner in which lights are installed in the poultry house has a bearing on their efficiency There must be a required amount of intensity of light at bird level Furthermore, the intensity must be uniform throughout the area or areas frequented by the birds

Distribution of bulbs In floor operations, a good rule of thumb is to follow the "1 to 1½" ratio, that is, the distance between bulbs should be 1½ times the distance from the bulb to the bird level If there are more than two rows of lights down the house, the bulbs in each row should be staggered to give better light distribution at floor level The distance from the bulbs to the outer edges of the house should be only one half the distance between bulbs

Distribution of the light bulbs may present more of a problem when cages are used The bulbs should be placed so that their rays fall on the feed supply and on the birds When the feeders are on the aisle side, a string of lights placed down the aisle will suffice But when the feeders are at the back, between two cages, there may be difficulty in getting uniform light distribution, particularly with multideck cages

Reflectors In most instances a clean reflector will increase the light intensity at bird level by about 50% compared with no reflector Avoid inverted cone-shaped reflectors They confine the light rays to too small an area Use a flat type or saucer type reflector with a rounded edge

In some instances bright, reflecting insulation is used on the inside of poultry buildings Although not as good as a regular reflector, these materials do reflect some light rays

Reflector pitch When reflectors are used, the pitch of the reflector will determine the area illuminated Although increasing the size of the bulbs will increase the lighted area when no reflectors are used, an increase in the bulb size will not illuminate a greater area when most reflectors are used, only the intensity is increased

Reflector size Reflectors should be about 10 to 12 in (25 4-30 5 cm) in diameter

If pullets are raised during the period of decreasing light days, they reach sexual maturity later than those raised during the period of increasing light days

Effects of Natural Daylight

To alter the age at which pullets reach sexual maturity, the poultryman manipulates his light management program so as to delay the onset of egg production With the environmentally controlled, dark house this is relatively easy, as all light is supplied artificially, but under natural daylight the program becomes complicated

In the Northern Hemisphere, spring hatched pullets are raised during a period in which the length of the natural light day increases until they are about half grown During the last half of their growing period the light day decreases in length, thus delaying the onset of egg production (Reverse the seasons for the Southern Hemisphere)

In the Northern Hemisphere, winter hatched pullets will complete their growing period during a time when the light days are getting longer, causing the pullets to lay their first eggs at a younger age (Reverse the seasons for the Southern Hemisphere)

If the requirement is for late sexual maturity, only those birds grown during the period when the natural light day is increasing necessitate a controlled program of lighting, to reverse the increasing light days to decreasing

Artificial Light in the Light proof House

Many pullets are raised in a light proof house where no natural daylight is allowed to enter Fan and other openings must be trapped to prevent any sunlight from getting into the building With such a house the length of the light day may be governed at will by the use of artificial lights There is no problem in following any program of light control

Results of Light Control

Delaying the onset of egg production by controlled lighting procedures not only increases the age at sexual maturity, but also affects other production factors Although much research has been conducted to determine the various results of light control, the following summarizes most of these findings All studies, however, have not produced conclusive evidence as listed below Some of the items represent small changes, hence sometimes are not definite

(1) Reducing the length of the light day during the growing period lengthens the time from one day of age until sexual maturity

(2) Reducing the length of the light day during the growing period increases the number of eggs laid during the first half of the egg production period, but does not greatly increase the total number of eggs laid during the entire period

(3) Reducing the length of the light day during the growing period materially increases the size of the first eggs laid, with a general increase in the size of all eggs produced during the first four or five months

(4) The maximum delay in the time for the pullets to reach sexual maturity through a program of reducing the length of the light day is about 3 weeks

of the eye filter out some of the shorter rays such as green, blue, and violet. In spite of the improvement in some color categories, white light is used almost entirely, as it represents the best average. Occasionally however, red light is used for the production of broilers in light tight houses.

The relationship between color of light rays and certain production factors are given in Table 18.3. In many cases the relationship is very slight.

TABLE 18.3

LIGHT COLOR RELATIONSHIPS

	Color of Light Rays				
Item	Red	Orange	Yellow	Green	Blue
Improves growth				X	X
Depresses feed efficiency			X	X	
Lowers age at sexual maturity				X	X
Increases age at sexual maturity	X	X	X		
Enlarges the eye					X
Reduces nervousness	X				
Lowers cannibalism	X				X
Increases egg production	X	X			
Lowers egg production			X		
Increases egg size			X		
Improves male fertility				X	X
Lowers male fertility	X				

Measuring Light Intensity

It is important to know the exact amount of light that is falling on the birds. There are so many factors that influence the *intensity of the light rays that any* recommendation can only be a guide. Secure a *light meter* and take an exact reading. These may be purchased or secured from a local light and power company. Take readings at several locations in the poultry house.

Time Clocks

Clocks which turn the lights on and off are used in poultry houses. Some have separate controls for a dimming system.

Warning Be sure to reset the clocks immediately after a power failure.

LIGHT EFFECTS DURING GROWING

One of the primary effects of light is the manner in which it alters the age at which pullets reach sexual maturity. It is not the intensity of light that produces all the difference, but rather, the length of the light day that alters the age of the bird at the time the first eggs are laid. As in one example, *decreasing the length of* the light day as the pullets go through their growing period increases the age at sexual maturity, increasing the length of the light day reduces the age.

Under natural sunlight the length of the light day is continually changing. It is longest on June 21st, and shortest on December 21st. Therefore, during half the year the light days become longer, during the other half, they become shorter

the pituitary and in turn the hormones of the follicle. Light falling on parts of the body other than the eye has no effect on the process.

Light increases feed consumption: Layers subjected to adequate light do eat more feed, but the increased consumption is the result of increased egg production. The original theory that the additional hours of light increased the amount of feed consumed because the birds had more time to eat and hence laid more eggs is not true.

Light Intensity Threshold

Although a lower intensity of illumination over a longer time will activate egg production as well as a brighter light for a shorter time, the former system is not commercially practical. Such continuous light disrupts the daily laying cycles of the birds, causing some to lay during the hours of natural daylight, while others lay during night-time hours. Flock maintenance procedures are disrupted to the extent that it takes most of a 24-hour period to gather eggs, feed the birds, and do other chores.

The practical recommendation is that there should be 1 footcandle of illumination at bird level. In houses with windows or openings, this intensity will be much higher during the hours of natural daylight. Only when artificial lights are used to supplement daylight will the minimum amount of light be necessary. In the light-tight house, 1 footcandle will be adequate during the entire light period of each day.

Although controlled experiments have shown that less than 1 footcandle is ample for egg production, it must be remembered that a poultry house is full of equipment which creates many shadows that reduce light intensity. This is particularly true of a cage operation. Thus the practical level of light is 1 footcandle. Table 18.4 shows the egg response from various intensities of light.

Light Intensity in Multideck Cages

Maintaining adequate light at all decks in multideck cages is very difficult. There seems to be no practical solution. When a light is hung overhead, the upper deck

TABLE 18.4

EGG PRODUCTION RESPONSE TO LIGHT INTENSITIES

Light Intensity Footcandles	Lux	Eggs Laid per Pullet Housed during 45 Weeks of Lay
0.01	0.1	208
0.02	0.2	221
0.03	0.3	223
0.08	0.9	222
0.11	1.2	223
0.16	1.7	231
0.35	3.8	233
0.54	5.8	240
0.81	8.7	239
1.83	19.7	242
2.68	28.8	242
3.98	42.8	240

Source: T. Morris, Dept. of Agr., Univ. of Reading, Reading, Berks., England.

(5) Feed restriction during the growing period also delays sexual maturity The maximum time of delay is about three weeks Meat type breeders are raised with feed restriction in order to maintain a reduced body weight, and a similar but less drastic program is often used for egg type lines Concurrent with the controlled feeding program is light restriction However, the delay in reaching sexual maturity is not cumulative Even if both programs are used simultaneously the maximum delay is usually not more than four weeks

All night lights first two days So that chicks may learn to eat and drink quickly, continuous 24 hour light should be used during the first 2 days With brooder cages, continuous light is often used for 4 to 7 days

Light Threshold

Although the intensity of the light during the growing period is not an important factor as long as it has a minimum of 1 footcandle, the hours of light per day are a factor If the length of the light day is less than 11 to 12 hours per photoperiod, sexual maturity and egg production will be retarded If the light day is longer, sexual maturity will be reached at a younger age and egg production will be initiated This threshold period of 11 to 12 hours is important in developing any satisfactory growing program It is the criterion used to produce one method of light restriction during this time period

Age For Maximum Growing Results

Preferably, reduced lighting programs during the growing period should start soon after the brooding period Some programs start when the chicks are three days of age Maximum results cannot be secured unless a light restriction program is started by the time the growing pullets are 12 weeks of age To wait longer reduces the length of time during light restriction, and full benefits cannot be realized However, there is more response to light restriction after 12 weeks than before

Light and Vices

Light supplied during the growing period should be reduced to a level of 1 foot candle at bird level Increasing the illumination above this figure will induce more cannibalistic characteristics Picking and feather pulling will increase, the birds may become highly nervous

LIGHT EFFECTS DURING EGG PRODUCTION

Not only does light affect the growing bird, but it stimulates the pituitary gland of layers to secrete the hormones necessary for egg production Under natural sunlight, hormonal secretions are activated once the total length of the light day reaches 11 to 12 hours, as in the spring months During the winter the length of the light day is not normally long enough to foster maximum egg production To increase the length of the light day in winter, artificial light must be used

How Light Stimulates

The light stimulus is initiated when light falls on the eye of the chicken This results in a change in the hypothalamus which increases the hormonal action of

egg production Most programs call for one to two hours more than this to provide a "safety" factor There is some indication that a light day of 17 hours or more will depress egg production in egg type strains

Light day must not be reduced During the laying cycle, the length of the light day may be increased, but *it can never be reduced* In a house with windows or openings this is very important, because the hours of natural daylight vary Thus, the hours of light supplied, either natural or artificial, must always be as great as the length of the longest day of the year during which the pullets will be kept in egg production

How to calculate If the longest day of the year has 15 hours of daylight, the length of the light day the rest of the year must never be less than 15 hours If it is, the light day will decrease during a part of the year

Time of Light During Photoperiod

Many scientists have tried to disarrange the periods of light and dark in the poultry laying house in an endeavor to increase egg production Some have shortened the photoperiod from 24 hours to 20 or 22 hours, with little effect With artificial light in a totally dark house it is possible, of course, to adjust the time of the hours of light and dark without altering the egg production cycle as long as a 24 hour photoperiod is maintained From a practical standpoint as a convenience to caretakers, the usual "day" is maintained, so that chores may be completed during normal working hours

How to lengthen the light day When artificial light is used to supplement the hours of natural daylight in the laying house, there are three practical procedures

(1) morning light,
(2) evening light,
(3) morning and evening light

The latter (3) is the best from a convenience standpoint The hours of light closely coincide with normal working schedules When morning (1) or evening (2) is used as the time for artificial light, there is also the inconvenience of having to adjust the time clock at least once a week to compensate for the daily difference in the time of sunrise or sunset

Dimmers When evening lights are used, dimmer bulbs may be necessary with some floor operations

Be careful about changing light Do not lower the intensity of artificial light or change from white to colored light during the laying period Be careful about using a temporary program of additional morning and evening light to increase feed consumption during hot weather

When should length of light day be increased There are several programs for lighting layers that increase the length of the light day throughout the laying year Most of these have proved impractical and are seldom used today However, there is some indication that meat type layers should be given a longer light day during the last month or six weeks of their laying cycle, to improve egg production during this period The normal light bulbs are kept lit all night, thus giving the birds a 24 hour light day It is doubtful if 24 hours of light during the last 4 to 6 weeks has any economic

receives a greater intensity of light than the lower In tripledeck cages of normal construction the illumination at the upper deck is from 3 to 3 5 times as great as the lower If a minimum amount of light is maintained for the lower deck, there is no egg production problem from the increased light at the upper However, increases in light intensity are correlated with certain vices, picking, cannibalism, prolapse and nervousness are more prevalent

Table 18 4 shows the effect of varying densities of light in tripledeck cages on egg production From a practical standpoint the only recommendation that can be made is that 1 footcandle of light must be maintained at the lower deck Although Table 18 5 shows a somewhat lower intensity, remember that dirty bulbs soon reduce the light intensity

TABLE 18.5

LAYING RESPONSE TO DIFFERENT LEVELS OF LIGHT INTENSITY IN MULTIDECK CAGES
(Windowless Houses)

Deck	Light Intensity at Each Deck Level Footcandles	Lux	Eggs Produced per Year
Top	3 44	37	240
Middle	2 32	25	242
Bottom	1 58	17	242
Top	0 70	7 5	239
Middle	0 46	5 0	240
Bottom	0 31	3 3	233
Top	0 14	1 5	231
Middle	0 09	1 0	233
Bottom	0 07	0 7	222
Top	0 03	0 3	223
Middle	0 02	0 2	221
Bottom	0 01	0 1	208

Source T Morris Dept of Agr Univ of Reading Reading Berks., England

Length of Light Period

The length of the natural light day varies not only by seasons, but according to one's location on the globe At the equator the sun is "overhead" most of the time and the daily hours of light and dark are more constant, but as one approaches the poles of the earth the position of the sun changes This influences the length of the natural daylight hours and the number of daily hours that artificial light must be provided to attain maximum egg production In the United States the longest day of the year has about 15 hours of daylight, the shortest, about nine However, the daily variations are as great as one hour depending on the location, and the poultry manager should secure a local schedule of daily sunrise and sunset, along with the length of the daylight hours Such schedules can be procured from his local weather bureau or similar agency These figures are very important in planning any lighting program for houses with open sides or windows

Total hours of light Although a light day of greater than 11 to 12 hours will stimulate egg production, the light day must be 14 hours for maximum

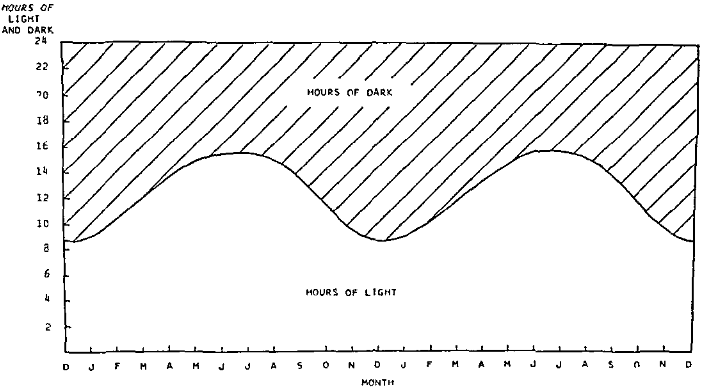


FIG 18 1 APPROXIMATE HOURS OF NATURAL DAYLIGHT IN THE NORTHERN HEMISPHERE BY MONTHS

Note Reverse the above and the following for the Southern Hemisphere

As a general rule, chicks hatched between March 1st and August 31st in the Northern Hemisphere may be raised in houses with windows or openings without any supplementary artificial light These "*in season*" *flocks* are grown during a period when the length of the natural light day is decreasing, at least during the last part of their growing cycle

(2B) *Reared in houses with windows or openings and during a period of increasing day length* When chicks are hatched between September 1st and February 28th, and are grown in houses with windows or openings, they spend at least the last half of their growing period when the length of the natural light day is increasing (Reverse for Southern Hemisphere) Referring again to Fig 18 1 the following examples are indicative of the picture

Examples

December hatch Each light day during the growing period gets longer

October hatch Each light day during the first half of the growing period gets shorter, but longer during the last half

These are the problem flocks and are known as "*out-of season*" *flocks* There is no way that they can be raised under only natural light, artificial light must be added Remembering that the length of the light day must at least not increase during growing, there are two common methods used to produce this effect

(a) *Constant light-day program* From a local table, determine the number of hours of daylight during the longest day until

value with egg type birds, since egg production is not always improved, any any improvement is usually slight

COMBINATION GROWING LAYING LIGHT PROGRAMS

To be most effective, the lighting programs for growing birds must be correlated with the lighting programs for layers There are dozens of such programs, but the common points of all are built around two important features

(1) The length of the light day should never increase for growing pullets

(2) The length of the light day should never decrease for laying pullets

Light program for entire life of pullet The type of lighting program used during the growing period will dictate the method of lighting during the laying period, therefore all programs are growing laying combinations

Classification of Growing Programs

Lighting programs for growing birds may be classified very briefly according to the time of year the birds are grown and whether the birds are kept in a light proof house or have access to natural daylight

(1) Reared in light proof houses

(2) Reared in houses with windows or openings

- (A) Reared during a period of decreasing length of natural light day
- (B) Reared during a period of increasing length of natural light day

Growing Light Programs

Using the above broad classifications, one finds some variations under each

(1) *Reared in light proof houses* From a management standpoint these programs are easy, as artificial light is the only source of illumination and the length of the light day can be controlled at will The most practical program is to keep the length of the light day below the threshold in order to delay the onset of egg production Although 11 to 12 hours of light represents the threshold, the actual length of the light day under these programs is about 8 hours to provide a safety factor A constant day length of 8 hours is maintained from the time the birds are about 3 days of age until they reach sexual maturity

(2A) *Reared in houses with windows or openings and during a period of decreasing day length* Birds in these houses have sunlight, the time of the year the day-old chicks are placed in the house will alter the lighting program, because it is almost impossible to start the chicks when all the days in the growing period have decreasing hours of natural light When birds are given this classification, one can only assume that the length of the light day will be *decreasing at least* during the last half of the growing period

Examples Referring to Fig 18 1, the following relationships be tween hatch days in the Northern Hemisphere and the lighting period show

June hatch Each day during the growing period gets shorter

March hatch Each day during the first half of the growing period gets longer, but shorter during the last half

maturity must coincide with increases in feed consumption. For the first few weeks after the flock starts to lay two things occur:

(1) Egg production increases rapidly.

(2) Body weight increases.

Each of the above changes requires additional feed to produce the desired effect. Many pullets, particularly those in the meat-type classification, are raised on a controlled feeding program in order to lower their body weight at sexual maturity. *If additional light is given at the onset of* egg production, but feed allocations are not increased, egg production will suffer. If the feed allotment is increased in the absence of additional light, the pullet will gain weight too rapidly because few eggs are being produced, and again, egg production will suffer.

Always remember: Start to increase the feed intake at about one week after you change from a growing light program to a laying light program.

Length of Light Day For Layers

In order to get maximum laying response from the layer lighting program, the total daily hours of light should be as follows:

Egg lines: 16-hour light day

Meat-lines: 15 to 15½-hour light day

Increasing light at sexual maturity: There is some evidence that sudden, large increases in the length of the light day at the time of sexual maturity are conducive to prolapse. Therefore, if a flock reaches sexual maturity with less than 11 to 12 hours of light, the length of the light day at the time egg production starts should never be increased to more than one hour greater than the threshold of 11 to 12 hours, or a maximum of about 13 hours. When the growing pullets receive more than 11 to 12 hours of light per day at the time they reach sexual maturity, the increase should not be more than one hour. After the first week of the increase, add one more hour of light per week until the pullets are receiving their required number of hours according to the program to be followed.

LIGHT TREATMENT AND PRODUCTION FACTORS

How Light Treatments Affect Production

Two of the ultimate aims of controlling the length of the light day during growing and egg production are to delay the onset of egg laying and to increase production efficiency. *Table 18.6 shows the influence of several different growing-laying* light programs on several production factors. Also of interest is the relation between the light threshold and the onset of lay. Gradually reducing the length of the light day during the growing period was not effective unless the light day was reduced below the threshold of 11 to 12 hours. Gradually reducing from 22 to 16 hours was ineffective in delaying sexual maturity, but gradually reducing from 22 to nine hours was.

Early Egg Size Affected by Light During Growing

It is common knowledge that when pullets are delayed in the onset of egg production, the first eggs are larger. The delay may be produced by restricting the

the flock reaches an average age of 20 weeks for egg lines or 21 weeks for meat lines When the chicks are three days of age provide this amount of total light (natural plus artificial) until the pullets begin to lay With this system there is never a decrease in the length of light day during the growing period

(b) *Decreasing light day program* From a local table, determine the number of hours of daylight when the flock reaches an average age of 20 weeks for egg lines or 21 weeks for meat lines Add seven hours to this figure The total will be the number of hours of light (natural plus artificial) the pullets are to receive the first week beginning with the third day Each week thereafter reduce the length of the total daily light period by 20 minutes until the pullets reach sexual maturity *The reductions will total about seven hours*

These programs not very effective Actually, these programs are a poor substitute for any of the other above methods At most times during the growing period the total light day is greater than the threshold of light response which is 11 to 12 hours Any benefit lies only in the fact that the length of the light day remains constant (a) or decreases (b), rather than increases

Growing laying Light Combinations

Inasmuch as light programs for growing pullets vary in respect to the total length of the light day at the time the birds reach sexual maturity, the method of lighting during egg production must be altered to be consistent with the growing program

Basic rule for making change to layer program The basic rule at the time *pullets are ready to produce eggs is that the length of the light day must* increase When the daily total hours of light supplied to the growing birds just prior to egg production is less than the *threshold of 11 to 12 hours,* the number of hours must be increased to above the threshold, usually to about 13 hours as a start

If the pullets reach laying age after a light program during growing that requires more hours of light than the threshold of 11 to 12 hours, the number of hours of light still must be increased

Age for changing to laying lighting program The growing light program must be changed to a laying light program at about the time the first eggs are laid However, flocks differ in the age at which they start egg production, depending on temperature, season of the year, the growing light program, and other factors Therefore, it is better to assign a fixed age for making the change If a flock comes into egg production early, it is better not to use more light until later, if the flock is slow in reaching sexual maturity, the laying light program will speed up the process The best age to change to the laying light program is 20 weeks for egg type pullets, 21 weeks for meat type pullets *Remember* that it takes 7 to 10 days for the light change to produce an effect

Feed intake must increase Increases in the length of the light day at sexual

Important Consult your chick supplier or genetic breeder for detailed instructions for the lighting program specific for his strain of birds.

(1) Reared in Light-proof Houses

When pullets are raised in light-proof houses, provide eight hours of artificial light each day after the second day until egg-type strains reach 20 weeks of age or meat-type strains reach 21 weeks of age. Do not alter the length of the light day during this period.

At 20 or 21 weeks of age, respectively, egg production begins and the birds may remain in a light-proof house or be moved to a house with open sides or windows The program for each is as follows·

(1A) *Left in light-proof laying house* When the laying pullets are to be left in a light-proof laying house, abruptly increase the length of the light day to 13 hours, then add 1 more hour per week until meat-type strains receive 15 hours of light or egg-type strains receive 16 hours of light.

(1B) *Moved to laying houses with open sides or windows* If the pullets are to be moved to houses with open sides or windows at 20 or 21 weeks of age, respectively, the length of the initial light day will be governed by the length of the natural daylight hours If they are less than 13 hours, use artificial light to supplement natural daylight so as to provide a 13 hour light day, then add one more hour per week until meat-type strains receive $15^1/_2$ hours of light, or egg type strains receive 16 hours of light

If the length of the natural light day is greater than 13 hours at 20 or 21 weeks of age, respectively, then add one more hour of light at this age, and increase 1 more hour per week until meat-type strains receive $15^1/_2$ hours of light or egg type strains receive 16 hours of light.

(2) Reared in Houses With Windows or Openings

(2A) *Reared in houses with windows or openings and during a period of decreasing day length* For chicks hatched between March 1st and August 31st, no supplemental artificial light should be given in these growing houses. Only natural daylight should furnish the illumination

When egg-type strains are 20 weeks of age or meat-type birds are 21 weeks of age, abruptly increase the length of the daily light period to 13 hours, then add one more hour per week until meat-type strains receive 15 hours of light in light-proof houses or $15^1/_2$ hours in houses with windows or openings Increase to 16 hours with all egg-type strains

(2B) *Reared in houses with windows or openings and during a period of increasing day length·* When chicks are hatched between September 1st and February 28th, and are raised in these houses, use one of the following light programs:

(a) *Constant light day program·* Determine the length of the longest natural light day before the pullets reach 20 or 21 weeks of

TABLE 18 6

INFLUENCE OF LIGHTING TREATMENT ON SEXUAL MATURITY, LAYING HOUSE MORTALITY, AND EGG PRODUCTION(1)
(S C White Leghorns in Cages)

Light Treatment		Days to Reach 10% Egg Production	Days to Reach 50% Egg Production	Laying House Mortality %	Eggs Produced during 47 Weeks of Lay
Growing Period	Laying Period				
Gradually decreased from 22 hrs to 16 hr	Gradually increased from 16 hr to to 22 hr	156	172	3 3	225
Gradually decreased from 22 hr to 9 hr	Gradually increased from 9 hr to 22 hr	172	186	3 3	220
Gradually decreased from 16 hr to 9 hr	Gradually increased from 9 hr to 16 hr	171	191	3 8	220
Gradually decreased from 16 hr to 9 hr	Suddenly increased from 9 hr to 16 hr	163	176	5 0	230
Started on constant 16 hr then suddenly decreased to constant 9 hr	Suddenly increased from 9 hr to 16 hr	165	176	4 6	227
Constant 16 hr	Constant 16 hr	156	171	5 0	224

(1) Average of two tests
Source J V Shutze, W E. Matson and J McGinnis 1963 *Poultry Sci.* 42 150–156

growing feed, or by using a proper lighting program. Early egg size is larger because the birds are older (egg size increases the older a bird gets) When she reaches a certain age she lays an egg of a certain size, regardless of the age at which she laid her first eggs This factor is of great economic importance, because first eggs are small in comparison with those laid later in the laying cycle Thus, delaying sexual maturity increases the percentage of the early eggs that will command a better price because of their larger market weight, or because they are more suitable for hatching purposes in the case of breeding birds

How Light Affects Males

Seemingly, the future fertilizing ability of the males is not affected by light intensities or the length of the light day during the growing period

During the breeding season, however, there is a relationship between light intensity and fertilization the lower the intensity, the lower the volume of semen produced However, the point has no practical application, as the intensity necessary for the pullets in the breeding pen to produce an adequate number of eggs also is satisfactory for the production of high semen volumes and good fertilization

Lights For Broilers

Refer to Chapter 20 for a discussion of the effects of light on broiler growth, feed conversion, and management

INSTRUCTIONS FOR GROWING AND LAYING LIGHT PROGRAMS

Although there are many lighting programs, the basic ones have been discussed in this chapter Explicit directions are given below for the use of the programs outlined above

Force Molting

Molting is a natural process of all birds in an endeavor to renew their feathers prior to migration, shorter days, or cooler weather. Normally, wild chickens molt once a year; as they produce but few eggs, the molt is not associated with the laying cycle. However, domestic chickens have been bred for high egg production, and under ordinary circumstances they do not go through a complete molt until the end of a long and intensive laying period. If nothing is done to alter the normal molting cycle, it requires about four months for a hen to drop her feathers and grow a new set. It is possible, however, to speed up the process through a program of forcing pullets to molt rapidly, growing a new set of feathers, then stimulating them to begin producing eggs. The entire artificial program should take no longer than eight to ten weeks.

Molting is evidently the result of the increase of some hormones and the decrease of others. The procedure is complicated and is not fully understood. Certain hormones and other chemicals, when injected into hens, will precipitate a molt.

Many hens are force molted at the end of their first period of egg production. In some areas of the United States as many as one-third of all first-year egg producers are molted. The procedure has gained in popularity during the last few years, and is now a management factor to be considered.

Reasons for Recycling

Force molting is practiced only to give the hen a rest at the end of a long period of egg production. It is but one method of producing the rest; certain chemicals will induce similar results. The ability of a hen to produce eggs well after the molt can be attributed only to the rest period she receives. Actually then, force molting is but a procedure for resting the bird so that she may continue her period of egg production during a so-called *second cycle.*

SECOND PRODUCTION PERIOD COMPARISON

After a force molt, egg production during the second cycle does not equal egg production during the first. This would present a severe economic problem if it were not for the fact that many of the costs of producing eggs during the second cycle are lower than those during the first cycle. Therefore, the practice of recycling becomes one of cost analysis. Some of the factors involved are:

(1) *Cost to bring to egg production:* It costs less to force molt a hen and bring her back into egg production than it does to grow a pullet from one day of age to egg production. This is a prime cost factor in making the decision of whether to molt or not to molt.

(2) *Amortization of bird cost:* The cost of growing the pullet, or the cost of force molting her at the end of her first cycle of lay and returning her to egg production, must be amortized over the number of eggs she produces. Although the molted hen has a lower cost than the pullet,

age Maintain this period of daily light hours from the third day until the birds are 20 or 21 weeks of age Supplement natural daylight with artificial light to keep the light day constant

At 20 weeks of age for egg type strains and 21 weeks of age for meat type birds, increase the length of the light day by 1 hour Make hourly increases each week thereafter until meat type strains receive 15 hours of light in light proof houses or 15½ hours in houses with windows or openings Increase to 16 hours with all egg type strains

(b) *Decreasing light day program* Determine the number of natural daylight hours when the pullets will reach 20 or 21 weeks of age, then add 7 hours to this figure The total represents the length of the light day from the third day until the end of the first week Thereafter, reduce the length of the light day by 20 minutes each week This should approximate 7 hours in 20 or 21 weeks

At 20 weeks of age for egg type strains and 21 weeks of age for meat type birds, increase the length of the light day by 1 hour Make hourly increases each week thereafter until meat type strains receive 15 hours of light in light proof houses or 15½ hours in houses with windows or openings Increase to 16 hours with all egg type strains

Altering the Above Directions

Although the above directions are quite specific as to the hours of total light that should be given on a specific week of age at a time approximating sexual maturity, it should be remembered that under most conditions the laying programs for lighting should be initiated at the time the first egg is laid by the flock Actually such light increases should precede laying feed increases by one to two weeks It will take from seven to ten days for additional light to produce its full effect, and birds should be producing well when the feed increase is given Otherwise bird weight may increase too rapidly

More Light at End of Laying Period

With meat type strains, continuous light should be supplied during the last 4 to 6 weeks of the laying cycle Such a program has little if any value for egg type layers

Be careful During hot weather, restriction of water has its disadvantages Birds will be less able to remove the heat from their bodies, panting will be excessive, and there may be dehydration and high mortality

(2) *Feed withdrawal* Practically all molting programs call for feed withdrawal, some for several days Others use a form of ration restriction whereby only whole grain is used for several days, to create the stress by means of an unbalanced ration Many programs call for the feeding of whole grain after the initial period of feed withdrawal in order to complete the molt

(3) *Light withdrawal* Practically all molting programs require reduction in the amount of illumination When this procedure is used, the period of daily light must be reduced well below the threshold of 11 to 12 hours This is an easy procedure in a light proof house, but in a house with windows or open sides it is impossible during the days with long hours of natural daylight However, when artificial light is used to supplement the hours of natural light, cutting off the artificial light will at least produce some effect and help initiate the molt

Combination Programs

There are many combinations of water, feed, and light withdrawal that will cause the birds to drop their feathers relatively quickly Removing the water and feed will cause the birds to lose weight, and this factor is of importance, rapid molting is associated with rapid weight loss, but rapid weight loss induces higher mortality The proper molting program is one that maintains a balance between the rapidity of the molt, proper weight loss, and low mortality

PROGRAMS FOR FORCE MOLTING

Of the many satisfactory molting programs, three that feature different basic procedures are given here

Conventional Molting Program

This program is outlined in Table 19 1 Some additional information is as follows

(1) Self feed oystershell from the start of molting until two weeks after egg production is reestablished, then return to controlled shell feeding
(2) Do not use skip a-day feeding programs until after ten days following the start of the molting procedure
(3) Provide adequate feeding space, all birds must be able to eat at one time
(4) Take one to two weeks longer to molt and force breeders to return to egg production

Washington Force Molting Program

Table 19 2 gives the details of this molting program Some additional notes are

(1) Provide feeder space adequate for all birds to eat at one time In cages where extra feeder space cannot be added, 12 lb of ration may be fed every other day to permit all hens to eat at once
(2) Self feed oystershell when starting the molting program Continue shell

she will not produce as many eggs during her second cycle as during her first This complicates the amortization value

(3) *Mortality comparison* The monthly rate of mortality usually is greater during the second period of egg production than during the first Although a highly variable figure, it could be up to 20% higher Thus, if the monthly mortality rate the first year were 1% it could be as high as 1 2% the second year

(4) *Feed consumption* Normally the daily feed consumption is only slightly higher the second year than the first However, because of increased mortality, feed consumption on a hen housed basis usually is higher the second year

(5) *Length of egg production period* The profitable period of egg production is longer during the first cycle than during the second Usually the second cycle lasts only 6 to 9 months

(6) *Rate of egg production* The rate of egg production is lower the second period compared with the corresponding month of the first period At the peak of egg production the rate will be about 90% of the first year production, but it will drop to as low as 80% after six months of egg production On a hen-day basis, second-cycle egg production will be about 83% of that during the first cycle, but because of higher mortality during the second cycle, egg production will be about 80% on a hen-housed basis

(7) *Egg size* Egg size is larger during the second cycle This becomes an advantage only if there is a market for the larger eggs

(8) *Shell quality* The average quality of the eggshells is much better during the first cycle than during the second Although eggshell quality is gradually reduced while the bird is in egg production, the molting rest usually restores the shells to first year normal for 3 or 4 months of egg production After this, shell quality in the force molted flock drops rapidly High environmental temperatures accentuate the decline

(9) *Interior egg quality* During the second cycle the contents of the eggs have a slightly lower quality than during the first About 10% fewer Grade A eggs may be expected during the second cycle compared with a similar production period during the first

METHODS OF FORCE MOLTING

There are several requisites to a good program of force molting Many programs will do the job well, but as stress must be created to cause the birds to drop their feathers, successful molting programs are those that create the least amount of stress, produce a rapid molt, and get the birds back into egg production quickly The three main factors involved are

(1) *Water withdrawal* Most, but not all, molting programs call for water restriction as one means of creating the stress necessary to produce the molt When it has been decided to force the molt, water is withheld for one or two days Some programs call for water restriction for 2 days, after which water is restored, and then removed for another 2 days

TABLE 19.3

MILO FORCE MOLTING PROGRAM
(No water restriction)

Day	Feed	Water	Light
1 through 35	No change	Water	Discontinue or provide 8 hours
36 through 45	None		
46 through 60–67	Full feed milo (or corn or wheat)		
61–68	Full feed laying mash		14–16 hours

Source The University of California.

dehydration is eliminated It is not a good program if the light day cannot be reduced to eight hours. On or about the seventh day without feed the flock will begin to look poorly However, *it should not be fed unless mortality starts to rise*. One or two days on feed after the ten-day starvation period will overcome the poor appearance. Production usually drops to zero on the sixth or seventh day. Self-feed oystershell during the molting process and until two weeks after the hens start producing eggs, then return to controlled shell feeding

CONSIDERATIONS INVOLVED WITH FORCE MOLTING

The results from force molting are subject to a great deal of variation Some flocks that are exceptional during their first cycle produce poorly during their second. In other cases, mediocre first-year flocks have a fine record after being molted. Many poultrymen consistently have poor results, while others find molting very profitable. There seems to be no way of estimating the behavior of the recycled flock.

Length of First-period Egg Production

Normally, flocks are force molted after 12 to 14 months of egg production; but in many instances, because of future favorable egg prices, it may be practical to start the molt after eight or ten months of production. This, of course, reduces the profit from the first cycle, but may increase the profit after force molting In some instances the flock may have laid poorly during the first cycle, and the caretaker may feel that it would be more profitable to molt early and rely on the second cycle for additional profit.

Flock of Good Quality

In spite of the fact that on occasion some flocks that are ordinary during the first cycle do exceptionally well the second, *it is wise to recycle only good first-year flocks*. The odds are greater that they will do better than poor first-year flocks.

TABLE 19 1

CONVENTIONAL FORCE MOLTING PROGRAM
(On again, off again program)

Day	Feed		Water	Light
1 2	None		None	8 hours
3	*Egg type layers* 10 lb (4 5 kg)/100 hens	*Meat type layers* 15 lb (6 8 kg)/100 birds	Water	
4	None		None	
5	Same as 3rd day		Water	
6	None		None	
7	Same as 3rd day		Water	
8	None		None	
9	Same as 3rd day		Water	
10 through 55–60	Return to controlled feed restriction—about 75% of full feed intake			
61	Full feed layer ration	Full feed breeder ration		14–16 hours

feeding until two weeks past the time the first eggs are laid, then return to controlled shell feeding

Milo Force Molting Program

Another method of force molting is called the *milo program*, or sometimes the *California program* It incorporates a long period of complete feed withdrawal followed by nothing but whole milo (or wheat or cracked corn) for a longer period As water is not restricted, it is a good procedure during periods of hot weather,

TABLE 19 2

WASHINGTON FORCE MOLTING PROGRAM
(Low feed intake)

Day	Feed		Water	Light
1	No change		Water	8 hours
2 3	None		None	
4			Water	
5	*Egg type layers* 6 lb (2 7 kg)/100 hens ↓ Until flock is less than 1% egg production then return to full feed	*Meat type layers* 8 lb (3 6 kg)/100 birds ↓ Until flock is less than 1% egg production then return to full feed		
50				14–16 hours

Source The Washington Experiment Station.

such poultrymen resort to force molting, because the cash outlay for force molting the flock is less

RECYCLING THE COMMERCIAL FLOCK

The practical application of recycling must be built around the ability of the poultryman to realize a higher return on his investment compared with his return when pullets are kept in egg production for only one laying cycle Although the commercial egg price is a very important factor in the formula, cost management comes under close scrutiny The flockowner must understand the fundamentals of force molting, what costs are involved, and how to keep expenses to a minimum if there is to be financial success

Comparison of Molting Programs

Although there are no available research results comparing the three force molting programs given in Tables 19 1, 19 2, and 19 3, the results of four methods of molting are given in Table 19 4 Most of the basic principles of molting are

TABLE 19 4

COMPARISON OF FOUR MOLTING PROGRAMS
(Sex linked Females)

Item	Force Molting Program			
	Feed removed first 10 days No water restriction Laying ration resumed on 11th day	Feed removed first 7 days Water withheld 2 days Laying ration resumed on 11th day	Feed removed first 10 days Water not removed Low protein feed 11–25 days Laying ration resumed on 25th day	Feed removed first 10 days. Water withheld first 4 days Low protein feed 11–25 days Laying ration resumed on 25th day
Body weight loss after 10 days on program (%)	21 8	18 8	21 3	17 7
Body weight loss after 25 days on program (%)	4 1	4 4	12 4	10 2
Body weight gain after 67 days on program (%)	4 1	6 4	3 3	5 7
Hen-day egg production 8 weeks after hens placed on laying ration(%)	57	65	54	47
When hens returned to 50% hen-day production				
1 Egg wt (oz/doz)	28 7	29 4	2[illegible] 8	2[illegible] 0
Egg wt (gm/ea)	67 9	69 5	6[illegible] 1	6[illegible] 4
2 Shell thickness (mm)	33 0	31 9	31 [illegible]	32 [illegible]
3 Haugh units	77 8	75 1	77 9	77 0

Source The University of Maine

Check for disease Before recycling any flock, take a few birds to the laboratory to determine if any diseases are present If a serious disease is present, it may alter the decision to force molt

Vaccinate About a week before the hens are to be force molted, vaccinate for bronchitis and Newcastle disease The laboratory technician may also recommend other vaccinations

Facilities

Housing the molted flock sometimes becomes an expensive item When recycled hens are to be left in the same house they used during their pullet year of egg production, the house will be far from full, thus raising the housing cost per bird and per dozen eggs produced Normally, one can expect to start no more than two thirds to three fourths the number of birds the second period as he did the first There will be a loss from first year mortality, loss during the molt, and a necessary amount of culling

As a matter of economics it is better to regroup molted birds, placing several groups in fewer houses after molting to make better use of house or cage space

Scheduling Other Replacement Pullets

Although many commercial poultrymen schedule molting as a part of their regular policy, and have a predetermined program for replacing certain flocks and molting others, many times the decision to force molt comes suddenly Unusual circumstances, such as a high death loss in a first-year flock, may preclude any possibility of profitably keeping the flock a second year Trying to take advantage of an obvious high egg price by keeping flocks a second cycle, as well as other factors, may disrupt the pullet replacement program All these factors must be considered before the decision to force molt is made

Molting as it Affects Hatchery Chick Sales

With such a high percentage of commercial egg producing pullets being force molted, it is obvious that the demand for day-old pullet chicks has decreased Except for the decrease in volume at the hatchery level, this is not an insurmountable problem However, a sudden decision to force molt often necessitates a cancellation or change of some confirmed chick order so that the house or cage space can be used for molted birds rather than for young pullets This then creates a problem at the hatchery level What can be done with the cancelled chicks?

When Poultrymen Recycle

Although most poultrymen plan their recycling programs well in advance, the economic circumstances that cause a sudden decision to carry a flock over for a second period of egg production are usually

(1) Anticipation of high egg prices
(2) Lack of available cash because of depressed egg prices

In these cases the cyclical effects of the ups and downs of the price the producer receives for his commercial eggs may mean that he has been producing eggs at a cost above their market value If this has been of long duration, many poultrymen find it financially difficult to accumulate enough ready cash to purchase a new group of chicks and to provide for them until they reach sexual maturity Many

produce eggs has been established in Chapter 14, Table 14.6. To arrive at the cost of force molting a commercial flock and returning it to egg production, the following items must be included:

(1) Market value of the spent hens in the flock at the time force molting begins.
(2) Feed from the initiation of force molting until the flock arrives at 5% egg production on a hen-day basis.
(3) Labor cost from the beginning of the molt until the flock reaches 5% egg production on a hen-day basis.
(4) Overhead and other costs during the molting period.

How to determine force molted hen cost The total of the above four *flock* costs, divided by the number of hens alive at the time the flock reaches 5% egg production on a hen-day basis is the value of one force molted hen when she returns to egg production.

Amortizing Molted Hen Cost

When the company books are kept on the accrual system, the cost of producing eggs during the first cycle must be divorced from those of producing eggs during the second cycle. The molted hen cost must be amortized over each dozen eggs she produces To state that force molting makes it possible to amortize the pullet cost over a longer period is a fallacy. Each period of production must be considered separately.

How much to amortize The cost of molting a hen, as detailed above, *minus* her salvage (market) value at the end of her second laying period is the amount to be amortized over her second cycle of egg production

Number of Eggs Produced

To compare egg production during the second period with that of the first period it is necessary to have the same starting point. In the comparisons in Table 19.5, the first week of egg production in each instance is the week when the flock produced at the rate of 5% on a hen-day basis. On the average, a second-year flock should produce about 83% as many eggs on a hen-day basis as it did during the same period the first year. However, the monthly variations are not uniform. The relative percentage is better at the beginning of the recycled period than during the latter part.

The figures in Table 19 5 can only be considered as good averages There is always the individual flock that produced about as well the second cycle as it did the first, particularly if the first-year egg production was relatively poor. Then there are flocks that were molted early the first year, perhaps after 9 or 10 months of production. During the second cycle, most of these seem to produce at a rate higher than average. But one must not forget the poor second-year flocks, which occur frequently. Many poultrymen have had such poor results from force molting that they refuse to try the program again. Much of the production data given in this chapter is the result of comparing flocks from all over the world. It is felt that the figures are somewhat better than average, although certainly not a goal which may be reached only occasionally.

Egg Size Comparison

One of the plus factors to be considered in studying the economics of recycling is that eggs produced the second year are larger than those produced the first

brought out in this experiment They are important to any successful program

(1) *Hens lose weight* Table 19 4 shows that after ten days on the molting program, hens had an average weight loss of about 20% This loss of weight not only is common, but is necessary if the hens are to drop their feathers quickly The weight loss on any program is associated with the severity of the feed withdrawal and the length of time the hens have a reduced feed allowance

(2) *Weight loss and mortality association* Usually the more severe the molting program, the greater the weight loss, and the greater the mortality Weight loss is not a problem except that mortality increases when the birds lose too much weight On most programs feed restriction may be continued as long as there is little excessive mortality

(3) *Weight loss regained* Once the hens drop to near zero egg production during the force molting program, the feed allowance should be increased, but only to the extent that it is ample for the birds to replenish their covering of feathers and to gain weight slowly In Table 19 4, notice that the hens had regained about half of the weight loss after they had been on the molting program for 25 days By the time a force molting program is completed, the body weight of the hens should approximate their weight at the time molting was first forced Once the body weight has returned to normal, the light day should be increased to 14 to 16 hours to stimulate egg production It is not wise to increase the length of the light day unless weight loss has been regained In Table 19 4, the heaviest birds after 67 days on the force molting program had the highest egg production after eight weeks on production feed, the lightest birds had the lowest egg production

(4) *Weigh the birds during molting program* Molting programs should not considered to be exact recommendations under all conditions Variations in the length of the natural light day, environmental temperature, condition of the hens at the time the program is initiated, and many other factors will alter the effects of the program One good criterion of how well force molting is progressing is to weigh regularly a representative sample of the hens Average flock weights should be taken just prior to molting, and every two weeks during the molting program

Comparison of First and Second Production Cycles

Before discussing the relative cost of producing commercial eggs during the first and second cycles of production, many of the items affecting cost and profit should be set forth

Pullet vs Molted Hen Cost

Although the cost of producing a sexually mature pullet is fairly well established, the cost of returning the molted hen to egg production is miscalculated in many instances The first year production period must be considered a separate entity from a bookkeeping standpoint It has nothing to do with the period after force molting The cost of raising a pullet from one day of age until she begins to

ing, their eggs are large during both the first and second cycles. The practical method of comparing egg size is to study the amount of increased size during the second period of lay for the same flock. Most first year flocks should produce eggs of a size so that at least 71% of them grade Large or over. Some strains will occasionally produce 80% of their eggs in this category. To give an indication of the egg size difference, one table that seemingly is about average is given. The egg size is compared on the basis of identical periods of egg production during the first and second cycles. It does not give the weights of all eggs produced during the first period of production. Such weights would be higher than those given.

Size of Birds

After force molting, hens will be larger than they were at the end of their first production period and they will continue to gain weight during the production period. It is a natural instinct for chickens to gain weight until they reach their maximum physical size, which is about the time they are two years of age. Leghorns should gain up to 0.5 lb (227 gm) during the second period of lay, medium-size birds laying brown shelled eggs, up to 0.75 lb (340 gm).

TABLE 19.6

FIRST AND SECOND PERIOD EGG SIZE
(Nine Months of Egg Production in Each Cycle)

Egg Weight Classification			
Oz per Dozen	Gm Each (Approximate)	1st Period %	2nd Period (after Force Molting) %
Over 29	Over 66.2	4.2	9.3
26 through 28	59.2–66.1	21.8	41.4
23 through 25	52.1–59.1	45.1	35.3
20 through 22	45.0–52.0	25.3	12.0
17 through 19	40.3–44.9	3.2	1.9
Under 17	Under 40.2	0.4	0.1

As feed consumption is related to body weight, one would expect the birds to eat more each day during their second period of production than during their first. This fact, along with decreased egg production, materially increases the feed consumed per dozen eggs produced in the second period of lay.

Egg Quality

The changes in egg quality in the second period of lay are variable. Although shell quality is good when laying starts in the post molt period, it deteriorates rapidly after about six months of egg production. Hot weather accentuates this drop. In most instances the shell condition becomes so poor after an extended period of egg production that the selling price of eggs is discounted.

Changes in interior egg quality are less variable than those associated with egg shell quality. Usually, decreases in interior quality are not a major economic factor.

Short-cycle Molting

When pullets are not kept for a full first production period of at least 12 months prior to force molting, the pullet year of egg production becomes a *short cycle*

TABLE 19 5

COMPARISON OF FIRST AND SECOND PERIOD COMMERCIAL EGG PRODUCTION
(Percent Hen day Egg Production)

Week	Leghorn 1st Period(2) %	Leghorn 2nd Period %	Medium size(1) 1st Period(3) %	Medium size(1) 2nd Period %
1	5	5	5	5
2	18	15	17	15
3	34	32	31	26
4	54	51	48	41
5	71	67	65	56
6	89	79	82	70
7	92	81	88	74
8	91	81	87	73
9	90	80	86	72
10	89	79	86	72
11	88	78	85	72
12	88	77	85	71
13	87	76	84	70
14	86	75	83	69
15	85	74	82	68
16	85	73	82	67
17	84	72	81	66
18	83	71	80	66
19	82	70	79	65
20	82	69	79	64
21	81	68	78	63
22	80	67	78	62
23	79	66	77	61
24	78	65	76	60
25	78	64	76	59
26	77	63	75	58
27	76	62	74	57
28	75	61	73	56
29	75	60	73	55
30	74	59	72	54
31	73	58	71	53
32	72	57	71	52
33	72	56	70	51
34	71	55	69	50
35	70	54	69	49
36	69	53	68	48
37	69	52	67	47
38	68	51	66	46
39	67	50	66	45
40	66	49	65	44

(1) Producing brown-shelled eggs
(2) Producing 240 eggs in 365 days hen-housed basis
(3) Producing 233 eggs in 365 days hen-housed basis

Since egg size is partially associated with body weight, one would expect that flocks that have gained appreciable weight by the end of the molting period would produce larger eggs However, these flocks also may produce fewer eggs

Certainly egg size during the second cycle is related to egg size during the first cycle Some strains of layers are bred for large egg size, and comparatively speak

cycle return more on invested capital than would have been the case if another group of first-year pullets had occupied the premises?

Approximate comparative costs for the first and second cycle of egg production are given in Table 19 8 The spread between the average cost for the two periods probably represents an average difference At times it could be higher, and at other times lower

TABLE 19 8

APPROXIMATE COMPARATIVE COST OF PRODUCING ONE DOZEN MARKET EGGS
(In U S Dollars)

Cost Item	Leghorn		Medium size(1)	
	1st Cycle	2nd Cycle	1st Cycle	2nd Cycle
Pullet growing cost(2)	$0 070		$0 083	
Molted hen cost(3)		$0 039		$0 050
Feed	150(4)	161	158(5)	177
Labor	010	010	010	010
Housing & equipment	019	022	021	024
Other costs	025	029	025	029
(Less) Hen salvage value	(010)	(016)	(015)	(017)
TOTAL	$0 264(6)	$0 245(7)	$0 282(6)	$0 273(7)

(1) Producing brown shelled eggs.
(2) See Table 14 6 Chapter 14
(3) See Table 19 7
(4) 60 lb (27 2 kg) @ $ 0375/lb ($ 082/kg)
(5) 66 lb (29 9 kg) @ $ 0375/lb ($ 082/kg)
(6) Average for 52 weeks of egg production (240 eggs)
(7) Average for 40 weeks of egg production (168 eggs)

Recycling Profit

The profit from recycling a flock of hens is derived from the value of the eggs sold These eggs should command a premium because of their larger size During the first full year of production a minimum of 71% of the eggs should be Large or over During the second period, a minimum of 86% should be in this size category However, unless the flockowner has provided for a special market for the larger eggs, this premium may not materialize Many buyers cannot use Extra Large and Jumbo eggs, and others offer no additional price for them

Keep Records

Force molting and recycling a flock calls for accurate decisions When should the flock be molted? Is the molt period progressing on schedule? How long should the hens remain in production during the second cycle? What are the costs and income? An adequate record system must be followed It will also serve as a guide to any future force molting program

RECYCLING THE BREEDER FLOCK

Breeder flocks used for the production of hatching eggs are often force molted and recycled However, the profitability of this program is materially lower compared with the program of molting the commercial flock because of

Sometimes the first cycle is shortened to 10 months, followed by a second cycle of 8 to 10 months Another popular recycling program is to induce 3 eight month periods of egg production by molting after the 1st and 2nd cycles A bird should produce about 480 eggs on a hen-day basis during the 3 periods

Short cycling costs must be kept separate The net cost of growing the replacement pullet must be amortized over the number of eggs she produces during the first period of egg production These costs cannot be carried over into a second or third period when the first period is short cycled If amortization is not complete when the flock is short-cycled, the balance must be charged against first period production, usually on the day force molting was begun It is just as much of a charge at that time as is an unusually high death loss the same day It is poor business to try to capitalize inefficiencies, and both excessive mortality and nonplanned molting are management inefficiencies Their cost must be written off the books as a direct flock expense the day they happen

Cost of Molting a Hen

One of the prime reasons for recycling is that it costs less to molt a hen and return her to egg production than it does to grow a replacement pullet Using Table 14 6, Chapter 14, the cost of growing a Leghorn pullet to *sexual maturity* is about US$1 40 and US$1 65 for a medium size pullet (producing brown shelled eggs) Estimated average cost of molting these two types of commercial layers and returning them to egg production is shown in Table 19 7

TABLE 19 7

ESTIMATED COST OF MOLTING A COMMERCIAL HEN(1)
(In U S Dollars)

Cost Item	*Leghorn*	*Medium size*(2)
Salvage value at end of 1st year of egg production	$0 20	$0 30
Feed(3)	22	24
Labor (including vaccinating and moving)	08	09
Other costs	06	08
(Less) Egg sales during molt	(08)	(10)
Mortality(4)	07	09
TOTAL	$0 55	$0 70

(1) From the day force molting begins until flock reaches 5% hen-day egg production
(2) Producing brown-shelled eggs
(3) Highly variable depending on force molting program
(4) Highly variable

Comparative Cost of Producing Eggs

The relationship between the cost of producing market eggs during the first and second cycles of egg production is an important feature of force molting Does it cost more or less to produce a dozen eggs after molting than during the first cycle? Another important question must be answered Will egg production the second

TABLE 19 9

PRODUCTION ESTIMATES FOR RECYCLED LEGHORN BREEDERS

Week of Egg Production	First Period Hen day Egg Production %	Second Period of Egg Production: Hen day Egg Production %	Cumulative Hatching Eggs per Hen Housed	Percent Total Hatch: Young Males %	Percent Total Hatch: Old Males %
1	5	5	0 4	78	73
2	16	15	1 4	81	76
3	34	31	4	84	79
4	54	50	7	85	80
5	72	66	11	85	80
6	85	78	17	85	79
7	88	80	22	84	79
8	87	80	27	84	78
9	87	79	33	84	78
10	86	78	38	83	77
11	85	77	43	83	77
12	84	76	48	83	76
13	84	75	53	82	76
14	83	74	58	82	75
15	82	73	62	82	75
16	81	72	67	81	74
17	81	71	72	81	74
18	80	70	76	81	73
19	79	69	80	80	73
20	78	68	85	80	72
21	78	67	89	79	71
22	77	66	93	79	71
23	76	65	97	78	70
24	76	64	101	78	69
25	75	63	105	77	69
26	74	62	108	77	68
27	73	61	112	76	67
28	73	60	116	76	67
29	72	59	119	75	66
30	71	58	123	75	65
31	70	57	126	74	65
32	70	56	129	74	64
33	69	55	132	73	64
34	68	54	135	73	63
35	67	53	138	72	63

Moltıng Breeder Males

If old males are to be used wıth the molted hens, the males should be molted at the same tıme. Thıs wıll prevent many males from moltıng durıng the second breedıng season, thus reducıng theır breedıng potentıalıty Use the same moltıng program for the males as for the females

Profitable Penod of Second-cycle Egg Productıon

The profıtable perıod of producıng hatchıng eggs durıng the second cycle for Leghorn and medıum sıze breeders ıs not as long as for commercıal hens Al-

(1) The added cost of providing for the males
(2) The increased value of the hatching egg compared with the commercial egg

Reasons for Recycling the Breeder Flock

The reason for recycling a commercial flock is to make an additional profit over a short period of egg production However, the reasons for a second period of egg production in the case of breeders are quite different They are

(1) *To supplement normal hatching egg production* In many instances, particularly in the case of egg type breeders, there are seasonal demands for day-old chicks that call for an increase in the number of hatching eggs Often it is more practical to supplement normal, first year egg production with eggs produced by flocks in their second cycle
(2) *Substitute for high growing mortality* Most hatcheries have a flock replacement schedule based on no excess of hatching egg production When a first year flock has high mortality, there may be a hatching egg deficiency In these cases, force molting an older flock may help to make up the difference in hatching egg numbers due to the high death loss in another flock
(3) *Unforeseen demand for chicks* The demand for chicks is difficult to project Many times it is greater than can be supplied by the available hatching eggs Recycling certain flocks offers a means of supplementing the egg supply

Comparison of Hatching Egg Production

Estimates of the production of hatching eggs during the first and second cycles of egg production are given in Tables 19 9, 19 10, and 19 11 It must be remembered that egg size is an important factor with breeding flocks, and post molted birds have a decided advantage in this respect

Recycling Requires Young Males

Young males produce much better fertility than old males force molted Only when the decision to force molt the breeding flock comes at a time late in the egg production period should old males be used with the recycled hens

When young males should be brooded It will be necessary to determine in advance when the molted hens will return to egg production Six months prior to this date the new group of matching males should be started in the brooder house This will allow time for them to grow and reach sexual maturity when the recycled hens begin producing hatching eggs

Forced Molting Programs for Breeder Hens

Any program of force molting that produces good results with a commercial flock of hens will be satisfactory for breeder hens However, it has been found that it should take from one to two weeks longer to return a breeder hen to egg production than in the case of a commercial hen Fertility, hatchability, and chick quality will be better if a slow molt program is used

TABLE 19.9

PRODUCTION ESTIMATES FOR RECYCLED LEGHORN BREEDERS

Week of Egg Production	First Period Hen-day Egg Production %	Second Period of Egg Production: Hen-day Egg Production %	Cumulative Hatching Eggs per Hen Housed	Percent Total Hatch: Young Males %	Old Males %
1	5	5	0.4	78	73
2	16	15	1.4	81	76
3	34	31	4	84	79
4	54	50	7	85	80
5	72	66	11	85	80
6	85	78	17	85	79
7	88	80	22	84	79
8	87	80	27	84	78
9	87	79	33	84	78
10	86	78	38	83	77
11	85	77	43	83	77
12	84	76	48	83	76
13	84	75	53	82	76
14	83	74	58	82	75
15	82	73	62	82	75
16	81	72	67	81	74
17	81	71	72	81	74
18	80	70	76	81	73
19	79	69	80	80	73
20	78	68	85	80	72
21	78	67	89	79	71
22	77	66	93	79	71
23	76	65	97	78	70
24	76	64	101	78	69
25	75	63	105	77	69
26	74	62	108	77	68
27	73	61	112	76	67
28	73	60	116	76	67
29	72	59	119	75	66
30	71	58	123	75	65
31	70	57	126	74	65
32	70	56	129	74	64
33	69	55	132	73	64
34	68	54	135	73	63
35	67	53	138	72	63

Molting Breeder Males

If old males are to be used with the molted hens, the males should be molted at the same time. This will prevent many males from molting during the second breeding season, thus reducing their breeding potentiality. Use the same molting program for the males as for the females.

Profitable Period of Second-cycle Egg Production

The profitable period of producing hatching eggs during the second cycle for Leghorn and medium-size breeders is not as long as for commercial hens. Al-

TABLE 19.11

PRODUCTION ESTIMATES FOR RECYCLED MEAT-TYPE BREEDERS

Week of Egg Production	First Period Hen-day Egg Production %	Second Period of Egg Production: Hen-day Egg Production %	Cumulative Hatching Eggs per Hen Housed	Percent Total Hatch: Young Males %	Old Males %
1	5	5	0.4	78	73
2	18	15	1.4	79	74
3	44	38	4	80	75
4	68	65	8	81	76
5	82	73	13	81	76
6	81	72	18	81	75
7	80	70	23	80	75
8	79	69	28	80	74
9	77	68	32	80	74
10	76	66	37	79	73
11	75	65	41	79	73
12	74	63	45	79	72
13	72	62	49	78	72
14	71	61	53	78	71
15	70	59	57	78	71
16	69	58	61	77	70
17	67	57	64	77	70
18	66	55	68	77	69
19	65	54	71	76	69
20	64	53	75	76	68
21	63	51	78	75	67
22	62	50	81	75	67
23	61	48	84	74	66
24	60	47	87	74	65
25	58	45	90	73	65
26	57	44	92	73	64
27	56	43	95	72	63
28	55	42	97	72	63
29	54	40	100	71	62
30	52	39	102	71	61
31	51	37	104	70	61
32	50	36	106	70	60
33	49	35	108	69	60
34	47	34	110	69	59
35	46	33	112	68	59

TABLE 19.11

PRODUCTION ESTIMATES FOR RECYCLED MEAT-TYPE BREEDERS

Week of Egg Production	First Period Hen-day Egg Production %	Second Period of Egg Production: Hen-day Egg Production %	Cumulative Hatching Eggs per Hen Housed	Percent Total Hatch: Young Males %	Old Males %
1	5	5	0.4	78	73
2	18	15	1.4	79	74
3	44	38	4	80	75
4	68	65	8	81	76
5	82	73	13	81	76
6	81	72	18	81	75
7	80	70	23	80	75
8	79	69	28	80	74
9	77	68	32	80	74
10	76	66	37	79	73
11	75	65	41	79	73
12	74	63	45	79	72
13	72	62	49	78	72
14	71	61	53	78	71
15	70	59	57	78	71
16	69	58	61	77	70
17	67	57	64	77	70
18	66	55	68	77	69
19	65	54	71	76	69
20	64	53	75	76	68
21	63	51	78	75	67
22	62	50	81	75	67
23	61	48	84	74	66
24	60	47	87	74	65
25	58	45	90	73	65
26	57	44	92	73	64
27	56	43	95	72	63
28	55	42	97	72	63
29	54	40	100	71	62
30	52	39	102	71	61
31	51	37	104	70	61
32	50	36	106	70	60
33	49	35	108	69	60
34	47	34	110	69	59
35	46	33	112	68	59

Meat-line breeder flocks cannot be profitably molted under ordinary circumstances. However, there may be occasions when the necessity for additional hatching eggs will be cause for recycling, even if the program is nonprofitable.

ANTIOVULATION DRUGS

It has been established that the basis for recycling is to give the hen a rest so that she may continue profitable egg production. Force molting is only a means toward this end. Today it seems to be the most practical method of producing

TABLE 19 10

PRODUCTION ESTIMATES FOR RECYCLED MEDIUM SIZE BREEDERS
(Producing Brown shelled Eggs)

		Second Period of Egg Production			
Week of Egg Production	First Period Hen day Egg Production %	Hen-day Egg Production %	Cumulative Hatching Eggs per Hen Housed	Percent T Young Males %	H[illegible] %
1	5	5	0 4	77	73
2	15	14	1 4	80	76
3	29	26	3	84	79
4	45	41	6	85	80
5	62	56	10	85	80
6	78	70	14	85	79
7	84	76	19	84	79
8	83	75	24	84	78
9	82	74	29	84	78
10	82	73	34	83	77
11	81	73	39	83	77
12	80	72	44	83	[illegible]
13	79	71	49	82	7[illegible]
14	78	70	53	82	7[illegible]
15	78	69	58	82	7
16	77	69	62	81	7
17	76	68	66	81	
18	76	67	71	81	
19	75	66	75	80	[illegible]
20	74	66	79	80	[illegible]
21	73	65	83	79	[illegible]
22	73	64	87	79	[illegible]
23	72	63	91	78	[illegible]
24	71	63	95	78	[illegible]
25	70	62	99	77	[illegible]
26	70	61	102	77	[illegible]
27	69	60	106	76	[illegible]
28	68	59	109	76	
29	67	58	113	75	
30	67	58	116	75	6
31	66	57	119	74	
32	65	56	123	74	[illegible]
33	64	55	126	73	
34	64	54	129	73	
35	63	53	132	72	

though eggshell quality remains fairly good for a relatively long period, bility drops off rapidly with continued post-molt egg production and makes periods of production less profitable In many cases, hatchability is reduced such a low level that it is unprofitable to set the eggs

Force molting the meat type breeder The meat type breeder (broiler breeder) is naturally a bird that consumes a large amount of feed in com parison with the number of eggs she produces The cost of carrying such birds through a molt is high Furthermore, the salvage value is greater than with egg type strains, and this increases the cost of the molted hen

TABLE 19 11

PRODUCTION ESTIMATES FOR RECYCLED MEAT TYPE BREEDERS

Week of Egg Production	First Period Hen-day Egg Production %	Second Period of Egg Production: Hen-day Egg Production %	Cumulative Hatching Eggs per Hen Housed	Percent Total Hatch: Young Males %	Old Males %
1	5	5	0 4	78	73
2	18	15	1 4	79	74
3	44	38	4	80	75
4	68	65	8	81	76
5	82	73	13	81	76
6	81	72	18	81	75
7	80	70	23	80	75
8	79	69	28	80	74
9	77	68	32	80	74
10	76	66	37	79	73
11	75	65	41	79	73
12	74	63	45	79	72
13	72	62	49	78	72
14	71	61	53	78	71
15	70	59	57	78	71
16	69	58	61	77	70
17	67	57	64	77	70
18	66	55	68	77	69
19	65	54	71	76	69
20	64	53	75	76	68
21	63	51	78	75	67
22	62	50	81	75	67
23	61	48	84	74	66
24	60	47	87	74	65
25	58	45	90	73	65
26	57	44	92	73	64
27	56	43	95	72	63
28	55	42	97	72	63
29	54	40	100	71	62
30	52	39	102	71	61
31	51	37	104	70	61
32	50	36	106	70	60
33	49	35	108	69	60
34	47	34	110	69	59
35	46	33	112	68	59

Meat line breeder flocks cannot be profitably molted under ordinary circumstances However, there may be occasions when the necessity for additional hatching eggs will be cause for recycling, even if the program is nonprofitable

ANTIOVULATION DRUGS

It has been established that the basis for recycling is to give the hen a rest so that she may continue profitable egg production Force molting is only a means toward this end Today it seems to be the most practical method of producing

the rest However, the requirements for replenishing the feathers and the loss of body weight create a great stress

Recently, several drugs and hormones have been used to produce a "vacation" or rest Most of these are in the category of antiovulation drugs They only prevent the hen from laying, she does not normally drop her feathers nor lose weight Although the results of their use have been very good, most experiments have shown that they are not quite equal to the results of forced molting Because it is possible to stop egg production at any time by administering the drug and to return the hen to egg production by withdrawing the drug, there are any number of combinations of programs that could be used to provide the hen with a rest The most common ones are

(1) *To delay the onset of egg production* Giving the drug at the time the bird reaches sexual maturity will delay the onset of egg production, allowing the pullet to gain weight and produce larger eggs when the drug is withdrawn

(2) *Year-end rest period* This is a substitute for forced molting The drug is administered for varying lengths of time However, there is a chance that there will be a normal molt after the drug is withdrawn, not from any drug connection, but because it is a natural age for molting

(3) *Intermittent rest periods* There are many combinations One example would be to feed the drug for two weeks out of every two months, thus giving the layer a periodic two week rest

Drugs in Combination with Force Molt

One antiovulation drug, *methallibure*, is used at 70 ppm in the feed Feed consumption drops to about 60% of normal and a molt follows The drug is fed for about 13 days while mash feeding continues After drug withdrawal, the birds increase their feed intake and egg production begins about eight or nine weeks after the drug was first fed

Caution Although methallibure has been cleared for use in some countries, it is illegal in others

Broilers and Roasters

Broiler production is a business in which volume is necessary to offset the small unit of profit. With margins so small, the producer, whether an individual operator or an integrator, must be aware of the many factors that affect the cost of production. Although each factor exerts only a minor influence, the combined effect of all factors becomes phenomenal. One might say that economical broiler production is "a lot of little things," none of which can be neglected.

Definitions of Broiler and Roaster

Through the years the meaning of these two terms has changed. Originally a broiler was a small chicken used for human consumption. A larger bird was known as a fryer. A bird still larger was called a roaster. Nowadays the term fryer is used less frequently, and broilers are birds that are marketed at an age of eight or nine weeks regardless of their size. In most instances their maximum live weight approximates 4 lb (1.8 kg). Roasters are much heavier. Straight run flocks average about 6.5 lb (2.95 kg).

Because of the similarity between many items in the broiler and roaster management programs, several recommendations are incorporated together in the following pages.

BROILER PRODUCTION

Broiler production began in 1923 on Delmarva Peninsula, as everyone knows, the growth of the industry has been phenomenal, not only in the United States, but around the world. In the early days, day-old broiler chicks were purchased from hatcheries producing heavy, meat-type breeds. Specialized feeds were soon developed, capable of promoting faster growth and improved feed conversion. As the industry increased in size, integration began to develop, necessitated because the margins of profit were shrinking in each segment of the business. Hatcheries and feed companies combined, processing was incorporated, and soon broilers were being produced on a contract basis rather than as a free-lance enterprise. In many countries at the present time most producers are growing broilers under a contract, that is, the integrator furnishes the chicks, feed, and some services, while the producer supplies the equipment, labor, and other incidentals. The integrator owns the birds at all times, the producer (grower) is paid a stipend for the use of his facilities and labor, usually on the basis of a unit of floor space, plus a bonus for doing a good job.

ALL IN, ALL-OUT SYSTEM

The most practical program for broiler rearing has been the use of the *all-in, all-out* system, in which only one age of broilers is on the farm at the same time. All the chicks are started on the same day, and later sold on the same day, after which there is a period when no birds are on the premises. This lack of birds breaks any cycle of an infectious disease, the next group of birds has a "clean start," with no possibility of contracting a disease from older flocks on the farm.

In the past it has been uneconomical to practice multiple brooding on a single farm Any disease in one flock soon finds its way to others, and as the new and younger groups of broilers reach a susceptible age, they too are attacked by the pathogenic organism To break the cycle of infection, the farm must be depopulated—certainly an uneconomical practice, as it takes eight weeks to get birds of all ages off the farm Then, following depopulation for 2 weeks, another 8 weeks are required to fill the buildings again.

Isolation

The broiler growing farm should be isolated No chickens of other ages should be nearby The buildings are best enclosed with a tight fence, and with locks on all entrance gates Beware of feed and other supply trucks entering the enclosure

The Broiler Growing Program

Broiler growing units have become larger as automation has made its way into the industry Certainly one man can easily care for 40 or 50 thousand birds with little difficulty As a contractor, he usually works every day until the birds are sold, then has his days off when the premises are depopulated. In some instances, one caretaker has handled over 100,000 birds with some extra help during the first week when the labor requirement is high

Broods per year The length of the growing period and that of the downtime (time between broods) vary, and in turn these variations affect the number of broods that can be started each year Normal downtimes range from 7 to 14 days A short downtime plus a short growing period increases the number of broilers that can be produced in a house during the

TABLE 20 1

LENGTH OF THE GROWING PERIOD DOWNTIME AND NUMBER OF BROODS PER YEAR

Length of Growing Period Days	Length of the Downtime in Days							
	7	8	9	10	11	12	13	14
	Number of Broods per Year							
49	6 5	6 4	6 3	6 2	6 1	6 0	5 9	5 8
50	6 4	6 3	6 2	6 1	6 0	5 9	5 8	5 7
51	6 3	6 2	6 1	6 0	5 9	5 8	5 7	5 6
52	6 2	6 1	6 0	5 9	5 8	5 7	5 6	5 5
53	6 1	6 0	5 9	5 8	5 7	5 6	5 5	5 5
54	6 0	5 9	5 8	5 7	5 6	5 5	5 5	5 4
55	5 9	5 8	5 7	5 6	5 5	5 5	5 4	5 3
56	5 8	5 7	5 6	5 5	5 5	5 4	5 3	5 2
57	5 7	5 6	5 5	5 5	5 4	5 3	5 2	5 1
58	5 6	5 5	5 5	5 4	5 3	5 2	5 1	5 1
59	5 5	5 5	5 4	5 3	5 2	5 1	5 1	5 0
60	5 5	5 4	5 3	5 2	5 1	5 1	5 0	4 9
61	5 4	5 3	5 2	5 1	5 1	5 0	4 9	4 9
62	5 3	5 2	5 1	5 1	5 0	4 9	4 9	4 8
63	5 2	5 1	5 1	5 0	4 9	4 9	4 8	4 7
64	5 1	5 1	5 0	4 9	4 9	4 7	4 7	4 7
65	5 1	5 0	4 9	4 9	4 8	4 7	4 7	4 6
66	5 0	4 9	4 9	4 8	4 7	4 7	4 6	4 6
67	4 9	4 9	4 8	4 7	4 7	4 6	4 6	4 5

course of a year. The effects of these two factors on the number of broods per year are shown in Table 20.1.

BROILER HOUSING

The practices followed in the growing of broilers are very similar to those used in the growing of commercial egg strains. Since housing, equipment, and management have been discussed in earlier chapters, the material included here will be confined to brief outlines of certain procedures, except where some item is especially pertinent to broiler raising.

Type of House for Broilers

Broiler houses may be considered as brooder houses. The only variation is that the birds are kept in them for two to four weeks longer than in the case of chick-type brooder houses. Such houses are described fully in Chapter 11, and it should be reviewed. In the main, there are two general types of housing suitable for broiler production.

(1) *Open house:* These houses are open to the extent that they have windows or open sides, depending on climatic conditions. Ventilation used is similar to that employed for brooder and grower houses used for other types of chicks.

(2) *Environmentally controlled house:* Such houses are lightproof. Ventilation is controlled according to the requirements of the birds.

Air requirement: The capacity of the ventilating system in the environmentally controlled broiler house should be that necessary when the broilers are at marketable weight and there are maximum outside temperatures. With 4.25-lb (1.9 kg) broilers and the temperature at 110°F (43.3°C), 5.6 cu ft of air per bird would need to be moved through the house each minute. As the requirement varies

TABLE 20.2

AGE OF BROILERS AND ROASTERS, TEMPERATURE AND VENTILATION NEEDS
(In Cu Ft of Air per Minute per Bird)

Outside Air Temperature		Approximate Age of Broilers and Roasters, in Weeks						
		2	4	6	8	10	12	14
		Approximate Average Straight-run Body Weight, in Pounds						
		0.5	1.4	2.6	3.9	5.3	6.5	7.5
		Approximate Average Straight-run Body Weight, in Kilos						
°F	°C	0.23	0.64	1.18	1.77	2.40	2.95	3.40
		Cubic Feet of Air per Minute per Bird						
40	4.4	0.24	0.7	1.2	1.9	2.5	3.1	3.6
50	10.0	0.30	0.8	1.6	2.3	3.2	3.9	4.5
60	15.6	0.36	1.0	1.9	2.8	3.8	4.7	5.4
70	21.1	0.42	1.2	2.2	3.3	4.5	5.5	6.3
80	26.7	0.48	1.3	2.5	3.7	5.1	6.2	7.2
90	32.2	0.54	1.5	2.8	4.2	5.7	7.0	8.1
100	37.8	0.60	1.7	3.1	4.7	6.4	7.8	9.0
110	43.3	0.66	1.8	3.4	5.1	7.0	8.6	9.9

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53	6 1	6 0	5 9	5 8	5 7	5 6	5 5	5 5
54	6 0	5 9	5 8	5 7	5 6	5 5	5 5	5 4
55	5 9	5 8	5 7	5 6	5 5	5 5	5 4	5 3
56	5 8	5 7	5 6	5 5	5 5	5 4	5 3	5 2
57	5 7	5 6	5 5	5 5	5 4	5 3	5 2	5 1
58	5 6	5 5	5 5	5 4	5 3	5 2	5 1	5 1
59	5 5	5 5	5 4	5 3	5 2	5 1	5 1	5 0
60	5 5	5 4	5 3	5 2	5 1	5 1	5 0	4 9
61	5 4	5 3	5 2	5 1	5 1	5 0	4 9	4 9
62	5 3	5 2	5 1	5 1	5 0	4 9	4 9	4 8
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°F	°C	*Cubic Feet of Air per Minute per Bird*						
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50	10.0	0.30	0.8	1.6	2.3	3.2	3.9	4.5
60	15.6	0.36	1.0	1.9	2.8	3.8	4.7	5.4
70	21.1	0.42	1.2	2.2	3.3	4.5	5.5	6.3
80	26.7	0.48	1.3	2.5	3.7	5.1	6.2	7.2
90	32.2	0.54	1.5	2.8	4.2	5.7	7.0	8.1
100	37.8	0.60	1.7	3.1	4.7	6.4	7.8	9.0
110	43.3	0.66	1.8	3.4	5.1	7.0	8.6	9.9

according to age of the birds and the temperature, Table 20 2 has been prepared to show the air requirement for broilers and roasters

Caution Fans do not always move their rated capacity of air Dirty blades, slipping belts, and baffles also reduce airflow If there is any doubt about the ability of fans to move air, increase the figures in Table 20 2 by 10 to 15%

Negative pressure ventilation In most, but not all cases, the negative pressure system is used to ventilate environmentally controlled broiler houses See Chapter 11

Pad-and fan cooling Many newly constructed broiler houses incorporate pad and fan cooling The value of this type of cooling is past the experimental stage When outside temperatures are high, such cooling increases broiler growth, feed consumption, and feed efficiency

Floor Space Per Broiler or Roaster

Floor space, at least to some extent, is inversely proportional to growth and feed conversion The more you crowd broilers and roasters, the poorer the results

Economics important Because of the above statement, an analysis of any floor-space experiment cannot be made solely on the basis of flock behavior Indeed, limiting the floor space gives poorer results on a bird basis, yet more pounds of meat may be produced in the broiler house The question always has been and continues to be What is the least amount of floor space necessary per bird to produce the greatest return on investment? Another fact is that larger birds require more floor space than smaller Thus, the size of the broiler or roaster to be marketed has a bearing on the computation

Reducing the floor space will

(1) Decrease feed consumption
(2) Decrease the growth rate
(3) Decrease feed efficiency
(4) Increase mortality
(5) Increase cannibalism
(6) Increase the incidence of breast blisters
(7) Increase the percentage of birds with poor feathering
(8) Increase the condemnations at the processing plant
(9) Increase the house ventilation requirement
(10) Increase the pounds of broilers raised in a given house during a 12 month period

Floor space and broiler or roaster size In the face of lower mature bird weight, decreased feed efficiency, and increased mortality, for greatest cash income per house approximately the amount of floor space given in Table 20 3 should be allocated to each bird Decrease the floor space per bird by about 10% during the winter months In other words, broilers and roasters need more floor space in hot weather than in cold

TABLE 20.3

FLOOR SPACE REQUIREMENTS FOR BROILERS AND ROASTERS

Weight of Mature Bird Lb	Kg	Floor Space Requirement Sq Ft per Bird	Sq M per Bird	Birds per Sq m
3	1.4	0.6	0.06	17.9
4	1.8	0.8	0.07	13.5
5	2.3	1.0	0.09	10.8
6	2.7	1.3	0.12	8.3
7	3.2	1.7	0.16	6.3

Floors vs. No Floors

In many locations concrete floors are a requisite of good house construction. However, where the soil is dry, porous, and sandy, many broiler and roaster houses are built so that the soil serves as the floor.

Size of Broiler House

There is no formula for determining the size of the broiler house, the dimensions being a combination of many factors. Where commercial production is practiced, few houses hold less than 10,000 broilers, and some hold 50,000 or more.

Width of house: The conventional house with windows or open sides should be about 32 to 36 ft (9.8–11.0 m) wide, but environmentally controlled houses should approximate 40 ft (12.2 m), because most automatic feeders better fit this width, and proper ventilation can easily be maintained.

Number of floors: Single floors are usually used for broiler production, although some poultrymen are using houses with two or three stories. However, the multistory house has the disadvantage of being more difficult to service. This is particularly true in regard to getting equipment, chicks, and feed to the upper floors. A greater difficulty occurs when the broilers are marketed; lowering the coops from the upper stories is very difficult and laborious.

Size of pens: Broilers do better if kept in groups not to exceed 2,000 birds. Pens are also advantageous at market time; it is easier to catch birds confined in pens.

BROILER GROWING EQUIPMENT

Practically all the equipment used in a commercial broiler growing house is similar to that necessary for keeping layer and breeder chicks to a similar age. See Chapter 12. However, some of the equipment capacities are different.

Brooders: Start 500 chicks under a 6-ft hover, 750 under an 8-ft hover, or 750 under a 40,000-Btu heater.

Feeders: Allow broilers 2 in. (5.1 cm) of trough space through 6 weeks, and 3 in. (7.6 cm) until market time at 8 or 9 weeks of age. When circular pans are used, allow about one-third less feeder space per bird.

Waterers Provide two chick founts for each 100 chicks at the start of the brooding period Later, each broiler should have 1 in (2 54 cm) of waterer space when troughs are used With pans, supply about one third less bird space

Lights Use continuous light the first 48 hours, then provide 0 5 footcandle of illumination at bird level to supplement natural daylight or in environ mentally controlled houses

Bulk feed bins These should be large enough to hold 1 ton (2,000 lb) of feed per 1,000 broilers

SELECTING THE CHICKS

Many of the factors associated with economical broiler and roaster growth are inherited Others are associated with the hatchery in which the chicks are hatched Decisions that must be made by the grower in selecting the best chick are listed below In many instances, the integrator is responsible for the choice of chicks, the producer must take the type and quality offered him as a part of his contract for growing the birds

(1) Which strain of broilers will be most profitable?
(2) What vaccination program have the breeders undergone?
(3) What is the breeder or hatchery disease-control program?
(4) What quality of chicks will be delivered?
(5) What is the chick size?
(6) Is there need for vaccinating at the hatchery?
(7) Are chicks to be sexed?
(8) Will the chicks need to be debeaked at the hatchery?

BROILER MANAGEMENT

Broiler management might be called *mini management* it involves a lot of little things many of which in themselves seem insignificant, yet add up to economical production The manager or caretaker who can care for all the details will achieve success, but the person who is careless, who forgets some "meaningless" chore, who does not know the intricacies of the business, or who fails to recognize problems in their infancy, will almost inevitably fail So many times in the broiler production business the *manager makes the difference* Today many flock managers are not as closely associated with their business as they were before integration gained a foothold in the industry, and when they had a greater financial interest in their business Today the man who actually cares for the flock is one of three types

(1) He owns the birds
(2) He is a contract grower
(3) He is a hired laborer

An analysis of the results obtained by Georgia broiler growers was made by the University of Georgia Broiler producers were classified according to the above three categories, and their ability to do a good job was analyzed A part of the results is given in Table 20 4 Those who owned their own birds had the highest broiler weights, the contract grower had the next best, and the laborer, the poorest The differences could not be associated with factors other than the type of

TABLE 20.4

BROILER WEIGHT ACCORDING TO TYPE OF CARETAKER

Type of Caretaker	Mature Broiler Weight Lb	Kg
Owner	3.43	1.56
Contract grower	3.40	1.54
Hired laborer	3.33	1.51

labor itself. The results do not mean that growers other than owners cannot do a good job, but they do show the necessity of a greater amount of exertion necessary to produce top results.

Preparing for the Chicks

A certain amount of downtime between broods of broilers is necessary to clean the house and premises. This also allows a period during which there are no birds in the buildings and provides an opportunity to break any cycle of an infectious disease. Preparation for the new group of broiler chicks during this downtime will encompass the following (See Chapter 13 for details):

Clean the house and equipment: Do as thorough a job of cleaning as possible. Use a disinfectant when needed. The litter may or may not be removed, according to the practice followed.

Litter: If the old litter has been removed, add new litter. When litter is reused, some additional new material may be necessary. There are many types of litter material, and that most likely to be used will be the most economical. But litters do differ, as Table 20.5 shows. Important too is the fact that the moisture-absorbing ability of the litter is not always correlated with broiler growth, as shown in this table.

TABLE 20.5

FACTORS ASSOCIATED WITH LITTER MATERIALS

Litter Material	Grams of Moisture 100 Gm of Litter Will Hold	Mature Broiler Weight on New Litter Lb	Kg
Pine Straw	207	3.35	1.51
Peanut hulls	203	—	—
Pine shavings	190	3.38	1.53
Chopped pine straw	186	—	—
Rice hulls	171	3.47	1.57
Pine stump chips	165	3.58	1.62
Pine bark and chips	160	3.40	1.54
Pine bark	149	3.39	1.54
Corncobs	123	3.57	1.62
Pine sawdust	102	3.57	1.62
Clay	69	3.24	1.47

Source: Univ. of Georgia Res. Bull. 75, Poultry Dept., Athens, Ga.

Qualities of a good litter A good litter should
(1) be light in weight,
(2) have medium particle size,
(3) be highly absorbent,
(4) dry rapidly,
(5) be soft and compressible,
(6) show low thermal conductivity,
(7) absorb a minimum of atmospheric moisture,
(8) be inexpensive,
(9) be compatible when sold as fertilizer

Clean the bulk feed bins Remove unused feed from the bins, then wash and disinfect them

Have the correct house and brooder temperature Both are very important to a proper start of the brooding operation See Chapter 13 for details

Attraction lights Where hover type brooders are used, install attraction lights to attract the chicks to the area of brooder heat during the first few days

Brooder guards With most brooders, guards are necessary to confine the chicks to the heated area

Warm room brooding Where the entire house is heated instead of using conventional brooding systems, be sure the building is heated to the correct temperature See Chapter 13

Feeders and waterers Chick box lids or something similar provide the most satisfactory feeder for the first few days Founts are best for supplying water

When The Chicks Arrive

A few hours before delivery of the chicks, fill the founts with water so that the chill will be removed by the time the chicks arrive Place fresh feed in the feeder lids after filling the waterers

Chicks should arrive early in the day So that the chicks may have the entire day to learn to eat and drink, they should be delivered early in the morning If they happen to arrive in the afternoon be sure that continuous light is used the first two nights

Care During First and Second Days

Keep the house warm
Be sure all the chicks are eating and drinking
Do not let chicks crowd against the guards
Give fresh feed often
Check the chicks often the first two days
Keep debris out of the water founts
Watch for starve outs Find the trouble and remedy it
Check the brooder temperatures at night
Be sure there is a coccidiosis-control program

Third and Fourth Days

Discontinue bright all night lights after 48 hours
Check the brooder temperature at night

Expand the brooder guards each day
Clean the waterers daily, disinfect them once a week
Start using larger feeders on the fourth day, but continue the feeder lids
Supply fresh broiler starter feed often
Be sure the length of the light day is correct

Fifth Through Seventh Day

Keep the brooder warm, the house cool
Check the brooder temperature at night
Clean the waterers daily, disinfect them once a week
Supply larger waterers
Start to remove first waterers and feeders
Remove the brooder guards
Begin to increase airflow through the house

Second, Third, and Fourth Weeks

Start to raise the feeders and waterers
Watch for feed wastage
Check the feed intake daily
Start raising brooder hovers at end of three weeks
Clean the waterers daily, disinfect them once a week
Keep the house cool
Increase the ventilation rate
Start the vaccination program
Be on the lookout for coccidiosis
Record daily feed consumption

Fifth, Sixth, and Seventh Weeks

Clean the waterers daily, disinfect them once a week
Increase the height of the feeders and waterers
Check the feed consumption
If hand fed, feed two or three times a day
If weather is hot, lengthen the light day
Change to broiler developer feed, usually at end of fifth week
Increase the ventilation, avoid drafts
With open sided houses, adjust the curtains as the outside temperature changes
Be on the lookout for disease

Eighth and Ninth Weeks

Wash waterers daily, disinfect once a week
Increase the height of the feeders and waterers
Keep the house cool
Increase the ventilation, avoid drafts
Check the daily feed consumption
If weather is hot, lengthen the light day
If hand fed, feed 2 or 3 times a day
Be on the lookout for disease symptoms
Follow any drug withdrawal requirement
Do not disturb birds the day they are marketed

LIGHT MANAGEMENT FOR BROILERS

The amount of light for a growing broiler is only that amount necessary to en able the bird to move about and to see to eat and drink Activity is to be reduced to a minimum The intensity of illumination at bird level should be about 0 5 footcandle In the environmentally controlled house, this requirement is easily provided, but with houses having open sides or windows more than this intensity of light is supplied by sunshine As illumination above the optimum induces cannibalism activity, and piling, *the open house is a decided disadvantage, unless* some method can be used to restrict some of the natural daylight But often this is not possible, which causes a problem

Colored Light

When the broiler house is lightproof, red light bulbs are often used to reduce cannibalism still further Debeaking usually can be eliminated But if the house has open sides or windows, the use of red lights during the morning and evening hours to supplement the hours of natural daylight is a disadvantage, as the birds cannot readily adjust to such an especially dim light after the bright, intense light of the daytime

Length of the Light Day

In most instances a light day of 14 hours will suffice for broilers There is no stimulating threshold as with layers, the only reason for an optimum light day is to provide sufficient time for the broilers to consume an adequate amount of feed and water When the weather is exceptionally hot it may be advantageous to pro vide a 16 hour light day to give some additional feeding time during the cooler hours in the morning and evening

Light For Catching Birds

Most broilers and roasters ready for market are removed from the poultry house at night, to reduce the incidence of bruising during the catching process A small amount of red or blue light will enable the catchers to see, while the chickens will *not be prompted to move about*

GROWING BROILERS IN CAGES

Although most of the world's commercial broilers are raised on the floor, some poultrymen believe that a revolutionary change could take place in the next few years with the advent of cage rearing Many experiments dealing with this method of management have been completed and some commercial broiler growers are testing the process

The cage system of producing broilers is designed after the one used for growing commercial laying pullets The broiler chicks are started in cages or coops with a mesh type floor and kept there until ready for market The main objective of the proper broiler cage has been to grow the birds in a coop that could be used to transfer the grown broilers to the processing plant As most of the present-day marketing coops are about 2 ft wide and 3 ft long (0 6 × 0 9 m), this size is pre dominately used for growing broilers The best growing program would involve the use of the same coop for starting and growing the broilers, but some systems of management call for special brooder starting cages Later, the broilers are moved to the cage coops Special equipment has been devised for feeding and

watering the broilers in the cage coops, and special coops to facilitate the labor associated with these two chores have been designed.

Although cage broiler growing is still in the experimental stage, certain advantages and disadvantages have been uncovered.

Advantages of cage growing

(1) More birds can be kept in a given house space, as the cages may be tiered.
(2) The system eliminates catching the birds at market time, reducing a great deal of bruising.
(3) There is no litter cost.
(4) Coccidiosis is practically eliminated.
(5) There may be less labor, although this is problematical.
(6) Cannibalism is reduced because of the dark house; no debeaking is necessary.
(7) Less downtime is necessary between broods; cleaning the house is easier.

Disadvantages of cage growing

(1) In most cases there is a higher incidence of breast blisters. At the present time most experimental work with broiler cages has to do with testing various types of cage-floor materials because the floor material is closely related to the incidence of blisters.
(2) There is a higher incidence of crooked keel bones in some instances.
(3) Cage-grown broilers are not as heavy as those grown on the floor.
(4) Feed efficiency is reduced.
(5) There is more "trim" of the birds in the processing plant. This reduces the monetary return for the birds.
(6) The wing bones are more brittle, a processing detriment.

Types of Cage Coops

Three types of cage coops are being tried, each associated with the material used in construction:

(1) wire coops;
(2) wood coops;
(3) plastic coops.

Type of Floor Material

In an endeavor to reduce the high incidence of breast blisters, about every conceivable type of material has been used for the cage floor. Wire fabric, punched plates, metal and wood dowel rods, solid floors, hardware cloth, rubberized rollers, rubber strips, foam-covered metal, and plastic mesh cloth are some of the materials tried. Surprisingly, the lowest incidence of breast blisters has occurred when welded wire fabric is used, but washed and scrubbed daily—a seemingly impractical solution to the problem.

If the breast problem can be reduced to that incurred with floor-reared birds, the practicability of cage rearing could become an established practice and perhaps revolutionize broiler growing.

Cage Specifications

Any program for growing broilers in cages is still in its infancy; there are few recommendations that have become specific. The floor space requirement is based

on the weight of the birds to be marketed Because of the close confinement, this is very important Provide a minimum of 0 1 sq ft (0 009 sq m) of floor space for each pound of average mature weight A 4 lb (1 8 kg) bird would require 0 4 sq ft (0 037 sq m), etc Crowding and bird weight increase the incidence of breast blisters Crowding reduces the mature bird weight and increases mortality Adjust the height of the feeder and waterer as the birds grow older

DISEASE PREVENTION

Management must provide a good program of disease prevention if successful broiler production is to result With broilers, as opposed to birds raised for egg production, there is but a short growing period—too short for the birds to recover from most disease outbreaks prior to market time Therefore, the disease-control procedure must be one of prevention rather than of treatment Only when there is failure in the prevention program can medication be practiced

Vaccination Program

There is no common vaccination program In fact, some broiler growers do not vaccinate for any disease, because they practice isolation and sanitation, and feel that these programs will prevent most disease outbreaks

When a vaccination program is to be followed, consult disease specialists in the area where the broilers are to be located, who are in an excellent position to know the prevalence of any disease, and the control measures necessary to prevent it As a *suggestion and starting guide, see Table 43 1, Chapter 43 In most instances* only Newcastle disease and bronchitis vaccines are used for broilers See a discussion of these diseases in Chapter 41

Remember Vaccination creates a stress Be sure to use the right type of vaccine, ascertain that it is fresh, vaccinate according to directions, and at the right age

Coccidiosis Control

After a study of coccidiosis, it would seem that there is a fool proof method for eliminating this disease in broilers But most methods are far from perfect, coccidiosis still is an important problem with broiler flocks

Complete suppression necessary Coccidiosis must be fully suppressed in broilers, there is not time to develop immunity Such a program calls for a coccidiostat at full level in the feed, or a vaccination program Even then there are failures See Chapter 41 Some method of treating flocks that "break" must be available on a moment's notice

Effect of a coccidiosis outbreak With coccidiosis there is damage to the intestinal lining which prevents normal absorption of food material from the intestinal tract Even mild outbreaks of the disease affect the condition of the birds Appetites are reduced, feed consumption is less than normal Reduced appetite and reduced intestinal absorption mean poorer growth and feed conversion, either of which could reduce the profitability of the flock

Medicaments

On many occasions it will be necessary to medicate a flock of broilers to alleviate the stress created by disease or by some management failure Most drugs

used in the course of treatment must be withdrawn from consumption some time prior to the day the birds are marketed, in order to eliminate or reduce the quantity of the drug in the tissues. Be sure you know the withdrawal period for each drug used.

GROWTH AND FEED CONSUMPTION

Anyone producing broilers or roasters must make a critical study of the variations that occur in the growth and feed consumption of males and females. These variations are shown in Table 20.6 (pounds) and Table 20.7 (kilos), and involve:

live body weight;
weekly increases in live body weight;
weekly feed consumption;
cumulative feed consumption;
weekly feed conversion;
cumulative feed conversion.

The data given in the tables represent average figures for good flocks. There are seasonal variations in these figures; one could expect slightly better results during the summer and poorer during the winter. The marketable weight of broilers varies, but most commercial broiler growers produce a bird near 4 lb (1.8 kg) in 8 weeks of time in the United States and in some other countries. When the average weight of the straight-run flock gets above 4.5 lb (2.04 kg), the birds are too heavy to be broilers and not heavy enough to be roasters. In this discussion a flock with an average straight-run weight of 4 lb (1.8 kg) each is considered to be marketable broiler size. Those weighing 6 lb (2.72 kg) and over are in a roaster classification.

From an examination of the data in Tables 20.6 and 20.7 the following facts may be established:

(1) *Males grow faster than females:* At near broiler market age, the males will attain approximately the same weight nine days before the females. See Table 20.12.

(2) *Weekly increases in weight are not uniform:* Gains increase each week until reaching a maximum at about the eighth week for straight-run flocks. Weekly weight increases of the females taper off prior to similar increases of the males.

(3) *Weekly feed consumption increases as weight increases:* Each week the birds eat more feed than they did the week before.

(4) *First gains require less feed:* Feed conversion, or the units of feed necessary to produce a unit of gain in weight, is lowest the first week, then increases each week thereafter. For example, a straight-run flock produces a unit (pound, kilo, or other measure) of gain the second week from 1.54 units of feed, but requires 2.59 units the eighth week.

(5) *Males convert feed to meat more efficiently than females:* A male weighing 3.5 lb (1.59 kg) requires about 6.79 lb (3.08 kg) of feed, while a female of the same weight requires 7.53 lb (3.42 kg) of feed. The feed conversion in each case is 1.94 for males and 2.15 for females.

(6) *The heavier the weight of the straight-run flock, the greater the percent-*

TABLE 20.6

GROWTH, FEED CONSUMPTION AND FEED CONVERSION
(In pounds)

	Males						Females						Straight run					
	Live Weight		Feed Consumption		Feed Conversion*		Live Weight		Feed Consumption		Feed Conversion*		Live Weight		Feed Consumption		Feed Conversion*	
Wk of Age	End of Wk	Wkly Gain	Wkly	Cumulative	Wkly	Cumulative	End of Wk	Wkly Gain	Wkly	Cumulative	Wkly	Cumulative	End of Wk	Wkly Gain	Wkly	Cumulative	Wkly	Cumulative
1	0.27	0.17	0.28	0.28			0.25	0.16	0.27	0.27			0.26	0.16	0.28	0.28		
2	0.55	0.28	0.43	0.71	1.52	1.30	0.51	0.26	0.40	0.67	1.56	1.32	0.53	0.27	0.41	0.69	1.54	1.31
3	0.98	0.43	0.74	1.45	1.72	1.48	0.88	0.37	0.67	1.34	1.79	1.52	0.93	0.40	0.70	1.39	1.75	1.50
4	1.50	0.52	0.98	2.43	1.87	1.62	1.32	0.44	0.85	2.19	1.96	1.67	1.41	0.48	0.92	2.31	1.91	1.61
5	2.11	0.61	1.23	3.66	2.02	1.73	1.81	0.49	1.04	3.23	2.12	1.79	1.96	0.55	1.14	3.45	2.07	1.76
6	2.80	0.69	1.53	5.19	2.20	1.85	2.34	0.53	1.23	4.46	2.34	1.91	2.57	0.61	1.38	4.83	2.27	1.88
7	3.57	0.77	1.80	6.99	2.34	1.96	2.89	0.55	1.39	5.85	2.50	2.02	3.23	0.66	1.60	6.13	2.42	1.99
8	4.42	0.85	2.12	9.11	2.49	2.06	3.48	0.59	1.60	7.45	2.72	2.14	3.95	0.72	1.87	8.30	2.59	2.10
9	5.27	0.85	2.30	11.41	2.71	2.16	4.03	0.55	1.64	9.09	2.99	2.26	4.65	0.70	1.98	10.28	2.84	2.21
10	6.04	0.77	2.31	13.72	3.00	2.27	4.56	0.53	1.79	10.88	3.38	2.39	5.30	0.65	2.02	12.30	3.11	2.32
11	6.74	0.70	2.32	16.04	3.31	2.38	5.06	0.50	1.88	12.76	3.76	2.52	5.90	0.60	2.10	14.40	3.50	2.44
12	7.39	0.65	2.38	18.39	3.62	2.49	5.53	0.47	2.05	14.81	4.36	2.68	6.46	0.56	2.20	16.60	3.93	2.57
13							5.97	0.44	2.27	17.08	5.16	2.86	6.98	0.52	2.32	18.92	4.46	2.71
14							6.37	0.40	2.44	19.52	6.10	3.06						
15							6.73	0.36	2.63	22.15	7.31	3.29						
16							7.05	0.32	2.80	25.01	8.94	3.55						

*Units of feed per unit of gain

TABLE 20.7

GROWTH, FEED CONSUMPTION, AND FEED CONVERSION
(in kilos)

	Males						Females						Straight-run					
	Live Weight		Feed Consumption		Feed Conversion*		Live Weight		Feed Consumption		Feed Conversion*		Live Weight		Feed Consumption		Feed Conversion*	
Wk of Age	End of Wk	Wkly Gain	Wkly	Cumulative	Wkly	Cumulative	End of Wk	Wkly Gain	Wkly	Cumulative	Wkly	Cumulative	End of Wk	Wkly Gain	Wkly	Cumulative	Wkly	Cumulative
1	0.12	0.08	0.13	0.13			0.11	0.07	0.12	0.12			0.12	0.07	0.13	0.13		
2	0.25	0.13	0.19	0.32	1.52	1.30	0.23	0.12	0.18	0.30	1.56	1.32	0.24	0.12	0.18	0.31	1.54	1.31
3	0.44	0.19	0.34	0.66	1.72	1.48	0.40	0.17	0.30	0.60	1.79	1.52	0.42	0.18	0.32	0.63	1.75	1.50
4	0.68	0.24	0.44	1.10	1.87	1.62	0.60	0.20	0.39	0.99	1.96	1.67	0.64	0.22	0.42	1.05	1.91	1.64
5	0.96	0.28	0.56	1.66	2.02	1.73	0.82	0.22	0.48	1.47	2.12	1.79	0.89	0.25	0.52	1.57	2.07	1.76
6	1.27	0.31	0.69	2.35	2.20	1.85	1.06	0.24	0.55	2.02	2.34	1.91	1.17	0.28	0.62	2.19	2.27	1.88
7	1.62	0.35	0.82	3.17	2.34	1.96	1.31	0.25	0.63	2.65	2.50	2.02	1.47	0.30	0.73	2.92	2.42	1.99
8	2.01	0.39	0.96	4.13	2.49	2.06	1.58	0.27	0.73	3.38	2.72	2.14	1.79	0.32	0.84	3.76	2.59	2.10
9	2.39	0.38	1.04	5.19	2.71	2.16	1.83	0.25	0.74	4.12	2.99	2.26	2.11	0.32	0.90	4.66	2.84	2.21
10	2.74	0.35	1.05	6.22	3.00	2.27	2.07	0.24	0.81	4.93	3.38	2.39	2.40	0.30	0.92	5.58	3.11	2.32
11	3.06	0.32	1.06	7.27	3.31	2.38	2.30	0.23	0.85	5.79	3.76	2.52	2.68	0.27	0.95	6.53	3.50	2.44
12	3.35	0.30	1.07	8.34	3.62	2.49	2.51	0.21	0.93	6.72	4.36	2.68	2.92	0.25	1.00	7.53	3.93	2.57
13							2.71	0.20	1.03	7.75	5.16	2.86	3.17	0.24	1.05	8.58	4.46	2.71
14							2.89	0.18	1.11	8.85	6.10	3.06						
15							3.05	0.16	1.19	10.05	7.31	3.29						
16							3.20	0.15	1.30	11.34	8.94	3.55						

*Units of feed per unit of gain.

age difference in weight between the sexes At 4 weeks of age the male weight is 113% of the female weight At 8 weeks it is 127%

Other Facts Pertaining to Growth

There are some other facts pertaining to growth that are impossible to put in table form

(1) Within a given flock, the larger males consume more feed than the smaller males, larger females more than smaller females
(2) Healthy birds consume more feed and have better feed conversion than sick birds
(3) Usually the more feed consumed, the better the feed conversion at a given age
(4) Exercise tends to reduce feed conversion
(5) Cannibalism induces nervousness, thereby lowering feed consumption and feed conversion
(6) Very high temperatures reduce feed consumption, causing a poorer feed conversion
(7) Growth and feed conversion are poorer during cold weather because a greater portion of the feed is used to maintain body temperature

Point Spread

A measure of feed conversion efficiency known as "point spread" has been used for a number of years to determine the nutritional efficiency of the feeding program

Definition of "point spread" Point spread is the difference between the average weight of the flock in pounds and the feed conversion

Examples

	Good conversion	Poor conversion
Average weight of a straight run flock	3 95 lb	3 45 lb
(Less) feed conversion	2 10	2.20
POINT SPREAD	185	125

Point spread may be a poor indicator of feed efficiency If one will study the point spread during the different weeks of growth for the normal flock, the figures will show that as the birds age the point spread becomes greater

Example

Age of broilers Wk	Straight run broiler weight Lb	Feed conversion to date	Point spread
6	2 57	1.88	69
7	3.23	1.99	124
8	3 95	2 10	185
9	4 65	2.21	244

Therefore, only when weights of different flocks are similar can point spread be used as an indicator for comparing feed efficiency.

WEIGHT SPREAD BETWEEN THE SEXES

At hatching time the males are but 1% heavier than the females. However, as birds grow, this spread increases, so that by the time broilers are at a marketable age, the spread will be much greater; the male weight will be approximately 127% of the female weight. The actual spread is more closely associated with weight than with age. Figure 20.1 shows this relationship on a weekly basis. The "curve" is linear.

Calculating Sex Weight Differences

Care should be taken in computing the variations in weight between the sexes. The system employed here is to compute the male weight as a percent of the female weight. If the figure were 125%, it would mean that the males were 25% heavier than the females. There are other methods. One is to determine the male and female weight variations from the average weight of a straight-run flock. Note

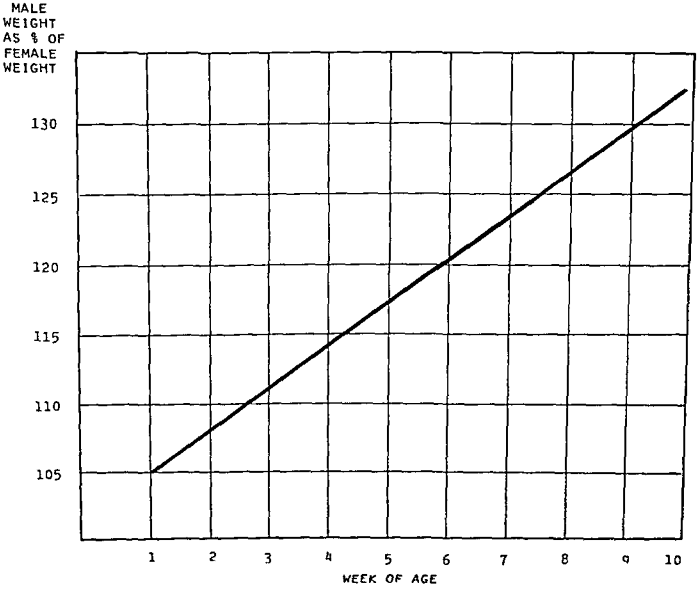


FIG. 20.1. MALE BROILER WEIGHT AS PERCENT OF FEMALE WEIGHT, BY WEEKS

the variations that occur when calculating the percentage differences in the following example

8 Weeks of Age	Male	Female	Straight run
Body weight (lb)	4 42	3 48	3 95
Body weight (kg)	*2 01*	*1 58*	*1 79*
Weight as % of female weight	127 0	0	113 5
Percentage weight increase (decrease) from straight run	+12 0	12 0	0

When the average weight of the males is 12% heavier, and the females 12% lighter than the mean (straight run), the males will be 27% heavier than the females

Sex Differences and What They Mean

The heavier a straight run flock of broilers, the greater the difference between the weight of the males and females One can expect a much wider difference in roasters than in broilers

As geneticists continue to breed their strains for increased growth, the weight variation between the males and females increases Genetic increases in growth have been going on for years, and will continue Eventually, the weight spread between the males and the females could become so great that it would be almost

TABLE 20 8

BROILER MALE WEIGHT AS PERCENT OF FEMALE WEIGHT WHEN THREE PARENT MALE LINES WERE MATED WITH SIX PARENT FEMALE LINES

Broiler Breeder Parents Male Line	Female Line	Broiler Male Weight as % of Female Weight
A	1	130
A	2	118
A	3	116
A	4	118
A	5	131
A	6	116
B	1	127
B	2	118
B	3	131
B	4	121
B	5	122
B	6	122
C	1	130
C	2	124
C	3	130
C	4	120
C	5	122
C	6	119

Source Arbor Acres Farm Inc Glastonbury Conn

mandatory that the sexes be raised separately so they could be marketed at comparable weights.

Rule of thumb: At marketable weight, broiler males will be 0.5% heavier than the females for each additional day kept on feed.

Sex Weight Differences Vary by Strains

To determine the weight variations between male and female broiler chicks, a test was conducted involving three parent male lines, each of which was mated with the same six parent female lines. The results are given in Table 20.8. As there were mature straight-run weight differences in the broilers from these 18 matings, and because weight influences the difference between the male and female broiler weight, the female broiler weights of all groups were converted to a 3.5-lb (1.59-kg) average. Notice the strain differences in the sex-weight relationships, along with the fact that these differences were not always consistent when another male was used.

FEED CONSUMPTION ACCORDING TO SEX

Because feed represents the largest expense item in the production of broilers, and because feed conversion varies according to the age, sex, and weight of the

TABLE 20.9

MALE BROILER FEED CONSUMPTION BY GROWTH INCREMENTS

Live Body Weight Lb	Feed Consumption: To Add Last 0.1-Lb Gain Lb	Feed Consumption: Cumulative Lb	Feed Conversion: To Add Last 0.1-Lb Gain	Feed Conversion: Cumulative
2.8	0.22	5.19	2.19	1.85
2.9	0.22	5.40	2.22	1.86
3.0	0.22	5.62	2.24	1.88
3.1	0.23	5.85	2.26	1.89
3.2	0.23	6.08	2.29	1.90
3.3	0.23	6.31	2.31	1.91
3.4	0.23	6.54	2.34	1.93
3.5	0.24	6.78	2.36	1.94
3.6	0.24	7.02	2.39	1.95
3.7	0.24	7.26	2.41	1.96
3.8	0.24	7.50	2.44	1.98
3.9	0.25	7.75	2.47	1.99
4.0	0.25	8.00	2.49	2.00
4.1	0.25	8.25	2.52	2.01
4.2	0.25	8.50	2.54	2.03
4.3	0.26	8.76	2.57	2.04
4.4	0.26	9.02	2.59	2.05
4.5	0.26	9.28	2.62	2.06
4.6	0.26	9.54	2.64	2.08
4.7	0.27	9.81	2.67	2.09
4.8	0.27	10.08	2.69	2.10
4.9	0.27	10.35	2.72	2.11
5.0	0.27	10.63	2.74	2.13

TABLE 20.11

STRAIGHT-RUN BROILER FEED CONSUMPTION BY GROWTH INCREMENTS

	Feed Consumption		Feed Conversion	
Live Body Weight Lb	To Add Last 0.1-Lb Gain Lb	Cumulative Lb	To Add Last 0.1-Lb Gain	Cumulative
2.6	0.23	4.92	2.27	1.89
2.7	0.23	5.15	2.30	1.91
2.8	0.23	5.38	2.33	1.92
2.9	0.24	5.62	2.37	1.94
3.0	0.24	5.86	2.40	1.95
3.1	0.24	6.10	2.43	1.97
3.2	0.25	6.35	2.47	1.98
3.3	0.25	6.60	2.50	2.00
3.4	0.25	6.85	2.53	2.02
3.5	0.26	7.11	2.57	2.03
3.6	0.26	7.37	2.60	2.05
3.7	0.26	7.63	2.63	2.06
3.8	0.27	7.90	2.66	2.08
3.9	0.27	8.17	2.69	2.09
4.0	0.27	8.44	2.72	2.11
4.1	0.27	8.71	2.75	2.13
4.2	0.28	8.99	2.78	2.14
4.3	0.28	9.27	2.80	2.16
4.4	0.28	9.55	2.83	2.17
4.5	0.29	9.84	2.86	2.19

cockerels. For example, in a *normal, healthy flock* when the males average 4.42 lb (2.01 kg) at eight weeks of age, the weight variations would be between 3.0 lb (1.36 kg) and 5.9 lb (2.68 kg). Normally the extremes are about 30 to 35% above and below the mean weight of each sex. Percentagewise, males vary more than females within a given flock, because the males are heavier. Even when each sex is the same weight, the males are more variable. Older birds of each sex show a slightly greater percentage variation in the weight of the individuals within the group.

The Normal Curve

If one were to weigh a group of broilers individually by weight intervals no greater than 0.1 lb (45.4 gm), and then separate the data by sexes, a further computation could be made to arrive at the number in each weight group as a percentage of the total. Figures for a *normal, healthy flock* are given in Table 20.13. They show the variations for the males, females, and the straight-run birds.

If the figures for the males and females in Table 20.13 are plotted on graph paper as percent of the population against live body weight, and lines drawn through the plotted points, two bell-shaped curves result. These are shown in Fig. 20.2.

When the figures for the straight-run flock are plotted, and the points connected, a bimodal curve appears, as indicated in the same figure. These three curves are very typical when body weight is studied. However, every strain of

bird, it is well that these variations—and their profit implications—be fully understood The next four tables deal with these factors

Male and Female Feed Consumption by Growth Increments

Feed consumption increases and feed conversion decreases as broilers age and get larger There are male and female variations In Tables 20 9, 20 10, and 20 11, body weight has been given in 0 1 lb intervals to show how feed consumption and feed conversion change as body weight increases One table is for male broilers, one for female, one for straight run It will be necessary to study these three tables carefully and relate the figures to the importance of feed costs

Time Necessary to Produce Males and Females of Same Weight

Time is an element of expense in the production of broilers As males will reach a desired weight several days before females, many cost calculations call for a table setting forth the number of days necessary to reach a desired body weight by sexes Such figures are given in Table 20 12

FLOCK WEIGHT VARIATIONS

One of the great economic problems of broiler production is that all birds are not the same weight at market time Not only are the males heavier than the females, but neither sex is uniform, there are small, medium, and large pullets and

TABLE 20 10

FEMALE BROILER FEED CONSUMPTION BY GROWTH INCREMENTS

Live Body Weight Lb	Feed Consumption: To Add Last 0 1 Lb Gain Lb	Feed Consumption: Cumulative Lb	Feed Conversion: To Add Last 0 1 Lb Gain	Feed Conversion: Cumulaitve
2 3	0 23	4 39	2 33	1 91
2 4	0 24	4 62	2 37	1 93
2 5	0 24	4 86	2 40	1 94
2 6	0 24	5 10	2 44	1 96
2 7	0 25	5 35	2 47	1 98
2 8	0 25	5 60	2 53	2 00
2.9	0 26	5 86	2 58	2 02
3 0	0 26	6 12	2 63	2.04
3 1	0 27	6 39	2 68	2 06
3 2	0 27	6 66	2.73	2 08
3 3	0 28	6 94	2 78	2 10
3 4	0 28	7 22	2 83	2 12
3 5	0 29	7 51	2 88	2 15
3 6	0 29	7 80	2.93	2 17
3 7	0 30	8 10	2 97	2 19
3 8	0 30	8 40	3 03	2 21
3 9	0 31	8 71	3 08	2 23
4 0	0 31	9 02	3 14	2.26
4 1	0 32	9 34	3 18	2 28
4 2	0 32	9 66	3 23	2 30
4.3	0 33	9 99	3 28	2.33

TABLE 20.11

STRAIGHT-RUN BROILER FEED CONSUMPTION BY GROWTH INCREMENTS

Live Body Weight Lb	Feed Consumption: To Add Last 0.1-Lb Gain Lb	Feed Consumption: Cumulative Lb	Feed Conversion: To Add Last 0.1-Lb Gain	Feed Conversion: Cumulative
2.6	0.23	4.92	2.27	1.89
2.7	0.23	5.15	2.30	1.91
2.8	0.23	5.38	2.33	1.92
2.9	0.24	5.62	2.37	1.94
3.0	0.24	5.86	2.40	1.95
3.1	0.24	6.10	2.43	1.97
3.2	0.25	6.35	2.47	1.98
3.3	0.25	6.60	2.50	2.00
3.4	0.25	6.85	2.53	2.02
3.5	0.26	7.11	2.57	2.03
3.6	0.26	7.37	2.60	2.05
3.7	0.26	7.63	2.63	2.06
3.8	0.27	7.90	2.66	2.08
3.9	0.27	8.17	2.69	2.09
4.0	0.27	8.44	2.72	2.11
4.1	0.27	8.71	2.75	2.13
4.2	0.28	8.99	2.78	2.14
4.3	0.28	9.27	2.80	2.16
4.4	0.28	9.55	2.83	2.17
4.5	0.29	9.84	2.86	2.19

cockerels. For example, in a *normal, healthy flock* when the males average 4.42 lb (2.01 kg) at eight weeks of age, the weight variations would be between 3.0 lb (1.36 kg) and 5.9 lb (2.68 kg). Normally the extremes are about 30 to 35% above and below the mean weight of each sex. Percentagewise, males vary more than females within a given flock, because the males are heavier. Even when each sex is the same weight, the males are more variable. Older birds of each sex show a slightly greater percentage variation in the weight of the individuals within the group.

The Normal Curve

If one were to weigh a group of broilers individually by weight intervals no greater than 0.1 lb (45.4 gm), and then separate the data by sexes, a further computation could be made to arrive at the number in each weight group as a percentage of the total. Figures for a *normal, healthy flock* are given in Table 20.13. They show the variations for the males, females, and the straight-run birds.

If the figures for the males and females in Table 20.13 are plotted on graph paper as percent of the population against live body weight, and lines drawn through the plotted points, two bell-shaped curves result. These are shown in Fig. 20.2.

When the figures for the straight-run flock are plotted, and the points connected, a bimodal curve appears, as indicated in the same figure. These three curves are very typical when body weight is studied. However, every strain of

TABLE 20 12

DAYS NECESSARY TO PRODUCE DESIRED WEIGHT, BY SEXES

Desired Live Body Weight		Days Necessary to Reach Desired Live Body Weight		
Lb	Kg	Males	Females	Straight run
2 6	1 18	40 3	45 2	42.3
2.7	1.23	41 1	46 5	43 3
2.8	1 27	42 0	47 8	44 4
2.9	1 32	42 9	49 1	45 5
3 0	1 36	43 7	50 4	46 6
3 1	1 41	44 6	51 7	47 6
3 2	1 45	45 5	53 0	48 7
3 3	1 50	46 3	54 3	49 7
3 4	1 54	47 2	55 6	50 7
3 5	1 59	48 0	56 9	51 6
3 6	1 63	48 9	58 2	52 6
3 7	1 68	49 8	59 5	53 6
3 8	1 72	50 6	60 8	54 5
3 9	1 77	51 5	62 1	55 5
4 0	1 81	52 3	63 4	56 5
4 1	1 86	53 2	64 7	57 5
4 2	1 91	54 1	66 0	58 5
4 3	1 95	54 9	67 3	59 5
4 4	2 00	55 8	68 5	60 5
4 5	2.04	56 7	69 8	61 8
4 6	2.09	57 5	71 1	62.5
4 7	2.13	58 4	72 4	63 5
4 8	2 18	59 2	73 7	64 6
4 9	2.22	60 1	75 0	65 7
5 0	2.27	61 0	76 3	66 8
5 1	2 31	61 9		67 9
5 2	2 36	62 3		69 0
5 3	2 40	63 6		
5 4	2.45	64 4		
5 5	2 49	65 3		

birds will vary, some are more uniform than others Furthermore, every group of broilers will vary

The Abnormal Curve

Unfortunately, all broiler flocks are not normal, healthy flocks Most have encountered some form of stress during the growing period Temperatures other than optimum, debeaking, mismanagement, medication, crowding, and other factors affect weight *variation* at market time The "bell-curves" will no longer be uniform the left hand side extends farther because stresses produce a higher percentage of smaller birds, the right hand side remains fairly uniform regardless of any reasonable stress The extent of the left hand malformation of the curve will depend on the severity of the stress The malformation is highly variable among flocks Because it is impossible to estimate the average effect of stress on the formation of the curves, the only reliable standard data must come from a "normal" curve, as shown in Fig 20 2

TABLE 20.13

DISTRIBUTION OF BROILER WEIGHTS IN THE NORMAL HEALTHY FLOCK
[Age, 8 Wk. Avg. Wt.: Male, 4.42 Lb (2.01 Kg), Female, 3.48 Lb (1.58 Kg), Straight run, 3.95 Lb (1.79 Kg)]

Weight of Birds		% in Each Weight Group		% in Each Weight Group in a Straight run Flock
Lb	Kg	Males	Females	
2.4	1.09		0.03	0.01
2.5	1.13		0.07	0.03
2.6	1.18		0.19	0.10
2.7	1.23		0.51	0.25
2.8	1.27		1.1	0.55
2.9	1.32		2.4	1.20
3.0	1.36	0.01	4.0	2.05
3.1	1.41	0.02	6.8	3.41
3.2	1.45	0.06	9.4	4.73
3.3	1.49	0.13	12.2	6.16
3.4	1.54	0.27	13.3	6.78
3.5	1.59	0.51	13.3	6.90
3.6	1.63	1.1	12.2	6.64
3.7	1.68	1.8	9.4	5.60
3.8	1.72	2.5	6.8	4.65
3.9	1.77	3.4	4.0	3.70
4.0	1.81	5.2	2.4	3.80
4.1	1.86	6.9	1.1	4.00
4.2	1.91	8.4	0.51	4.45
4.3	1.95	9.3	0.19	4.74
4.4	2.00	10.3	0.07	5.18
4.5	2.04	10.3	0.03	5.16
4.6	2.09	9.3		4.65
4.7	2.13	8.5		4.25
4.8	2.18	6.9		3.45
4.9	2.22	5.2		2.60
5.0	2.27	3.5		1.75
5.1	2.31	2.5		1.25
5.2	2.36	1.8		0.90
5.3	2.40	1.1		0.55
5.4	2.45	0.51		0.25
5.5	2.49	0.27		0.13
5.6	2.54	0.13		0.07
5.7	2.59	0.06		0.03
5.8	2.63	0.02		0.02
5.9	2.68	0.01		0.01

What Percent of Broilers Are Within Weight Requirements?

Many processors sell broilers that command a premium when within maximum and minimum live weights. Any birds between the two extremes are suitable for their use, but those outside the extreme must be considered as by-products, and many times must be sold at a discount. The broiler grower is interested in this requirement too; he wants to know what percent of his flock will fall within certain weight limitations. By referring to Table 20.13, he can determine this.

Problem: The processor's requirement is for birds no less than 3.5 lb (1.59 kg) and no greater than 4.6 lb (2.09 kg). What percent of the flock will

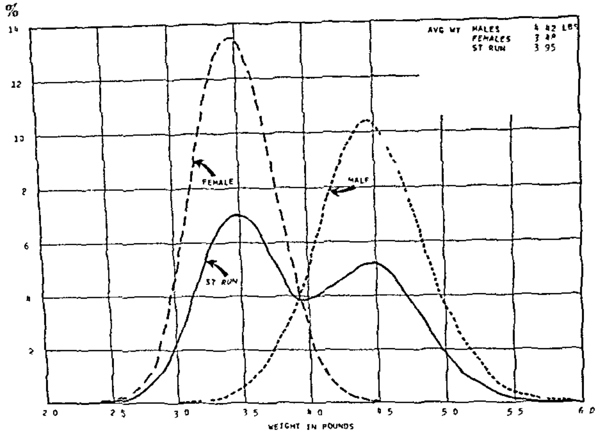


FIG 20.2 DISTRIBUTION OF BROILER WEIGHTS IN THE NORMAL HEALTHY FLOCK (8 WEEKS OF AGE

fall between these weights when the average straight run flock weight is 3 95 lb (1 79 kg)?

Solution Refer to Table 20 13, and add the percentage figures between the above weight extremes They will total as follows

Males	69 01%
Females	50 00%
Straight run	59 47%

FEEDING BROILERS

Feed formulation and other details regarding the feeding of broilers are given in Chapter 37 Broiler feed formulation is one thing, correct usage of the feed is another

Broilers should be full fed from start to finish They should be induced to eat as much feed as possible, for the more they eat, the faster they grow, and the faster they grow, the better the feed conversion In most instances, two types of feed are used

(1) *Starter ration* Ordinarily this is fed from the start until the broilers are about 5 weeks of age, although some poultrymen use a prestarter for the first 2 weeks The prestarter contains more protein to induce better growth, and more antibiotics to aid in disease prevention

(2) *Finisher ration.* At about five weeks of age, a finisher ration is substituted for the starter. It should be lower in protein and higher in energy. Where a broiler with dense yellow pigment is necessary, the finisher ration should contain more pigmenting ingredients.

Form of feed: Broiler feed comes in three forms:

Mash: Mash is usually used for at least two weeks, but may be fed throughout the entire growing period.

Crumbles: On occasion, broilers are started on crumbles, but generally this form of feed is not given until the birds are two or three weeks of age.

Pellets: When the chicks are four weeks of age, they will consume pellets in preference to mash, and most broiler feeding programs call for pellets at this age. Usually, they are not fed prior to this time, as the chicks cannot eat pellets readily because of their size. Pellets have an advantage in broiler feeding. Birds eat more feed when it is pelleted, and the feed conversion is better.

Feed Conversion

Feed is the major item of cost in producing a broiler. Therefore, the price of feed and the feed conversion are especially important to economical production. The relationship between feed price and feed conversion is given in Table 20.14.

Seasonal variation in feed conversion: Depending on the environmental temperature, broiler feed conversion is better during the summer than during the winter. The difference may vary as much as 5% above, and 5% below the average conversion for the entire year.

Example: If the average feed conversion of all broilers produced in a house during a year were 2.1, during the winter the conversion could be as low as 1.995, and as high as 2.205 during the summer, other things being equal.

BROILER PRODUCTION COSTS

The cost of producing a pound (or kilo) of live broiler is highly variable from farm to farm, season to season, and country to country. The ability of the bird to convert feed to meat is important; yet there are many factors that affect its efficiency in doing this. Table 20.15 is one example of estimated broiler production costs. The figures would be representative in those areas with average feed costs and efficient production.

BROILER CONDEMNATIONS

Although most of the broilers produced are suitable for human consumption, some are not. Since 1959 in the United States, about 85% of dressed and eviscerated broilers produced have been slaughtered under some type of inspection, either federal, state, local, or voluntary. Since 1966, nearly 2.5% of all broilers so processed have been condemned. The percentage varies greatly by processing plant and state. Surprisingly, the percentage condemned has shown an increase through the years. In 1970 it was 3.98%. It must be remembered, however, that

TABLE 20.14

FEED COST AND FEED CONVERSION AS THEY AFFECT THE FEED COST PER POUND OF BROILER

Feed Cost		Feed Conversion (Lb of Feed per Lb of Live Weight)														
Per Ton* (US $)	Per Lb (US ¢)	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40	2.45	2.50
		Feed Cost per Pound of Broiler (In U S Cents)														
110	5.50	9.90	10.18	10.45	10.73	11.00	11.28	11.55	11.83	12.10	12.38	12.65	12.93	13.20	13.48	13.75
109	5.45	9.81	10.08	10.36	10.63	10.90	11.17	11.45	11.72	11.99	12.26	12.54	12.81	13.08	13.35	13.63
108	5.40	9.72	9.99	10.26	10.53	10.80	11.07	11.34	11.61	11.88	12.15	12.42	12.69	12.96	13.23	13.50
107	5.35	9.63	9.90	10.17	10.43	10.70	10.97	11.24	11.50	11.77	12.04	12.30	12.57	12.84	13.11	13.38
106	5.30	9.54	9.81	10.07	10.34	10.60	10.87	11.13	11.40	11.66	12.93	12.19	12.46	12.72	12.99	13.25
105	5.25	9.45	9.71	9.98	10.24	10.50	10.76	11.03	11.29	11.55	11.81	12.08	12.34	12.60	12.86	13.13
104	5.20	9.36	9.62	9.88	10.14	10.40	10.66	10.92	11.18	11.44	11.70	11.96	12.22	12.48	12.74	13.00
103	5.15	9.27	9.53	9.79	10.04	10.30	10.56	10.82	11.07	11.33	11.59	11.85	12.10	12.36	12.62	12.88
102	5.10	9.18	9.44	9.69	9.95	10.20	10.46	10.71	10.97	11.22	11.48	11.73	11.99	12.24	12.50	12.75
101	5.05	9.09	9.34	9.60	9.85	10.10	10.35	10.61	10.86	11.11	11.36	11.62	11.87	12.12	12.37	12.63
100	5.00	9.00	9.25	9.50	9.75	10.00	10.25	10.50	10.75	11.00	11.25	11.50	11.75	12.00	12.25	12.50
99	4.95	8.91	9.16	9.41	9.66	9.90	10.15	10.40	10.64	10.89	11.14	11.39	11.63	11.88	12.13	12.38
98	4.90	8.82	9.07	9.31	9.56	9.80	10.05	10.29	10.54	10.78	11.03	11.27	11.52	11.76	12.01	12.25
97	4.85	8.73	8.97	9.23	9.46	9.70	9.94	10.19	10.43	10.67	10.91	11.16	11.40	11.64	11.88	12.13
96	4.80	8.64	8.88	9.12	9.36	9.60	9.84	10.08	10.32	10.56	10.80	11.04	11.28	11.52	11.76	12.00
95	4.75	8.55	8.79	9.03	9.26	9.50	9.74	9.98	10.21	10.45	10.69	10.93	11.16	11.10	11.64	11.88
94	4.70	8.46	8.70	8.93	9.17	9.40	9.64	9.87	10.10	10.34	10.58	10.81	11.05	11.28	11.52	11.75
93	4.65	8.37	8.60	8.84	9.07	9.30	9.54	9.77	10.00	10.23	10.46	10.70	10.93	11.16	11.39	11.63
92	4.60	8.28	8.51	8.74	8.97	9.20	9.43	9.66	9.89	10.12	10.35	10.58	10.81	11.04	11.27	11.50
91	4.55	8.19	8.42	8.65	8.87	9.10	9.33	9.56	9.78	10.01	10.24	10.47	10.69	10.92	11.15	11.38
90	4.50	8.10	8.33	8.55	8.78	9.00	9.23	9.45	9.68	9.90	10.13	10.35	10.58	10.80	11.03	11.25
89	4.45	8.01	8.23	8.46	8.68	8.90	9.12	9.35	9.57	9.79	10.01	10.24	10.46	10.68	10.90	11.13
88	4.40	7.92	8.14	8.36	8.58	8.80	9.02	9.24	9.46	9.68	9.90	10.12	10.34	10.56	10.78	11.00
87	4.35	7.83	8.05	8.27	8.48	8.70	8.92	9.14	9.35	9.57	9.79	10.01	10.22	10.44	10.66	10.88
86	4.30	7.74	7.96	8.17	8.39	8.60	8.82	9.03	9.25	9.46	9.68	9.89	10.11	10.32	10.54	10.75
85	4.25	7.65	7.86	8.08	8.29	8.50	8.71	8.93	9.14	9.35	9.56	9.78	9.99	10.20	10.41	10.63
84	4.20	7.56	7.77	7.98	8.19	8.40	8.61	8.82	9.03	9.24	9.45	9.66	9.87	10.08	10.29	10.50
83	4.15	7.47	7.68	7.89	8.09	8.30	8.51	8.72	8.92	9.13	9.33	9.55	9.75	9.96	10.17	10.38
82	4.10	7.38	7.59	7.79	8.00	8.20	8.41	8.61	9.82	9.02	9.23	9.43	9.64	9.84	10.05	10.25
81	4.05	7.29	7.49	7.70	7.90	8.10	8.30	8.51	8.71	8.91	9.11	9.32	9.52	9.72	9.92	10.13

*2,000 lb

TABLE 20.15

ESTIMATED COST TO PRODUCE A POUND OF BROILER
(In U.S. Dollars)

Item	Explanation	Cost per Lb of Live Broiler at 4-lb Avg Weight	Cost per Kilo of Live Broiler at 1.8-kg Avg Weight
Chick	$0.08 + 5% mortality	$0.021	$0.046
Feed	2.1 conversion, $0.045/lb ($0.099/kg)	0.095	0.209
Contract grower payment		0.021	0.046
Services		0.001	0.002
Vaccine		0.002	0.004
Condemnations	2.4%	0.004	0.009
Total		$0.144	$0.316

all the increase is not due to a greater number of birds of poor quality going to market; some of it is the result of more rigid plant inspection.

Condemnations during the winter are about twice as high as those during the summer; thus there is a seasonal variation. Another important factor is that the entire bird may not always be judged unacceptable for human consumption; many times only a part of the bird is so classified. In these instances, the part is cut off or out. An example would be a severe breast or wing bruise.

Bruises and Condemnations

Some have said that the processing loss from bruising and the consequent downgrading is as great as that due to condemnation from disease. Certainly bruises represent a severe economic loss to the broiler industry. The situation is deplorable when one realizes that most bruising is the result of improper handling of the birds just prior to and during catching and hauling.

Facts about bruises: The following are reasons for some of the bruising in broilers:

(1) Females bruise more easily than males. Usually there are about twice as many females as males with bruises.
(2) Within each sex, the larger and older the bird, the greater the incidence of bruising.
(3) There will be fewer bruises when the broilers are raised under low light intensities.
(4) Crowding during growing increases the percentage and severity of the bruises.
(5) The use of dim light in the broiler house during catching will reduce the incidence of bruises.
(6) Most bruises are the result of improper handling during the 24-hour period prior to slaughter.
(7) The method of handling during marketing is more closely associated with bruises than any other factor.

Recommendations to prevent bruises

(1) Keep the litter from getting wet
(2) Provide adequate floor space
(3) Handle the birds carefully during catching, hauling, and removing from coops
(4) Do not excite the broilers during the day prior to catching When excited, birds hit the feeders and waterers, causing bruises
(5) Trucks used to haul the birds should not come near the broiler house until after dark Truck noises excite the birds during daylight hours
(6) Train the catching crews to handle the birds carefully
(7) Remove all floor equipment after dark, just before catching the birds
(8) Use dim blue or red lights in the house during catching and cooping
(9) Catchers should not carry too many birds at one time The more birds carried, the higher the percentage of bruising
(10) Place the birds in the coops carefully
(11) Truck loaders should not throw the coops
(12) Personnel who unload the chickens should use caution in removing the birds from the coops
(13) Make a study of the causes of bruising, then detail a program to remove the causes

PROCESSING FACTORS

Of interest to the broiler grower are the variations that take place at the processing level, for in many instances these have a bearing on the type, weight, and age of bird that the grower produces

Age and Sex Associated with Processing

Table 20.16 shows the variations in dressing percentage, eviscerated yield, and chilling gains for broilers of varying ages and weights The table clearly shows

(1) The heavier the bird, the lower the percentage of blood and feathers
(2) When the sexes are the same weight, the percentage loss from blood and feathers is greater in the males
(3) It is possible to restore a higher percentage of eviscerated weight loss in the females than in the males

TABLE 20.16

EFFECT OF AGE AND SEX ON PROCESSING WEIGHT LOSS

Week of Age	Live Weight				Loss in Blood and Feathers		Eviscerated Weight as % of Live Weight*		Chilling Gains	
	Males		Females		Males	Females	Males	Females	Males	Females
	Lb	Kg	Lb	Kg	%	%	%	%	%	%
6	2.7	1.23	2.2	1.00	12.6	13.7	66.1	64.7	8.7	9.9
7	3.3	1.50	2.7	1.23	11.9	12.0	66.6	65.7	8.4	9.3
8	3.9	1.77	3.1	1.41	11.9	12.7	67.4	65.9	8.5	9.0
9	4.6	2.09	3.6	1.63	11.1	11.9	68.2	68.0	7.6	9.0
10	5.4	2.45	4.2	1.91	11.0	12.1	69.7	69.7	7.4	7.9

*Does not include giblets
Source H. L. Orr and E. T Morgan *CANADIAN POULTRY REVIEW* July 1968

Yield of Parts at Processing

Sex has little effect on the yield of cut-up parts. Other than the thighs and drumsticks, which are longer in the male, the sex differences in weight of cut-up parts are slight. These percentages are shown in Table 20 17.

TABLE 20 17

YIELD OF CUT UP PARTS AS PERCENT OF CHILLED CARCASS BY SEXES

Item	Males	Females
Live weight (lb)	3 9	3 1
Live weight (kg)	*1 77*	*1 41*
Percent yield		
Wings	13 1	13 2
Thighs	18 7	18 4
Drumsticks	15 3	14 8
Breast	31 7	32 1
Back	13 4	13 2
Neck	7 8	8 3

Source H L Orr and E T Morgan *CANADIAN POULTRY REVIEW* July, 1968

BROILER RECORDS

The necessity of records cannot be overemphasized as a part of the broiler production program Without careful records there is little indication of the economic progress of the flock Certain records must be compared with a set of *standards* if there is to be any assurance that the flock is as good or better than average. There are three types of broiler records

(1) those involved with growing the flock,
(2) those involved with making the contract settlement,
(3) those involved with determining profit or loss

The most important parts of each record keeping system are given below

Those Involved with Growing the Flock

date broiler chicks started
house number and location
grower's name
number of chicks started, by sex or straight-run
source of chicks
floor space per chick
name of feed manufacturer
type of feed used, including any medication
Daily record of
- feed consumption
- water consumption
- mortality
- feed delivered
- vaccinations and medications
- management notes

Weekly record of
- mortality
- body weight
- feed consumption for flock
- feed consumption per live bird at end of week
- feed conversion to date

Final record of
- date birds were sold
- age of birds at time of sale
- to whom birds were sold
- weight of birds sold
- number of birds sold
- percent mortality
- average weight per bird sold
- percent condemned in processing plant (weight)
- pounds of feed used
- pounds of feed used per bird sold
- pounds of feed used per pound sold
- feed conversion
- selling price per pound (if applicable)

Those Involved With Making the Contract Settlement
- name of integrator
- name and location of grower
- square feet of floor space in house and per bird started
- date broilers were sold
- number of chicks started
- number of broilers sold
- age of broilers sold
- percent mortality
- pounds of feed used
- pounds of broilers sold
- pounds condemned at processing plant
- percent condemned at processing plant (pounds)
- feed used per live broiler sold
- feed conversion
- base contract payment
- bonus contract payment
- total contract payment
- return to grower per 1,000 broilers produced

Those Involved With Determining Profit or Loss

This record is a list of income and expenses connected with each group of birds and is primarily for the integrator, although it could be used by the independent operator

Income
- net received from the sale of broilers (Do not deduct condemnations, as they are a cost item)

other income
total income from the venture

Expenses:
chick cost
feed cost
feed delivery cost
sanitation and medication cost
vaccination cost
debeaking cost
flock service cost
fuel cost
litter cost
other consumable supplies cost
condemnation cost
grower payment cost
other costs
total costs

Net profit or (loss)
for the flock
per bird marketed
per pound marketed

ROASTER MANAGEMENT

When meat-type chickens are grown to live weights between 6 and 8 lb (2.72–3.63 kg), they are known as roasters in many countries. They are not to be confused with fowl (old hens or roosters) in this weight category. Roasters are young birds, grown similarly to broilers, but to a heavier weight. In fact the management program for roasters is quite similar to the program for broilers up until live body weight reaches 4.5 lb (2.04 kg), after which adjustments in the ration and some management practices must be made.

Age and Weight of Roasters

Maximum growth in a short period of time is a requisite to economical roaster production. Certain strains of meat-type birds are especially suited to rapid growth to roaster weight, while others are not. In many instances some strains grow rapidly to broiler weights, but weekly growth increments are poor at larger sizes. Be sure to select a strain of birds that has the genetic potential to attain roaster weight rapidly and economically.

Tables 20.6 and 20.7 show the growth rate of meat-type birds up to roaster weights. Notice that the increments of weekly gain become smaller after birds reach seven weeks of age. This is an important factor in roaster production.

Feed Conversion

The *units* of feed necessary to produce *one unit* of gain in live weight (feed conversion) are given in Tables 20.6 and 20.7. These figures are of value when studying the economics of roaster production, for as birds increase in size, the amount of feed necessary to produce a pound of gain increases materially. Although a pound of live broiler may be produced on about 2.1 lb (0.95 kg) of feed, it will require approximately 2.7 lb (1.23 kg) of feed to produce 1 lb of live roaster.

Male and Female Roasters

As males grow more rapidly than females, the time consumed in getting a male to roaster weight is much less than for a female It will take approximately 11 5 weeks to get a male to the required weight, but about 16 weeks for a female

In many instances the day-old chicks are sex separated and raised separately One sex or the other may be sold at broiler weight, and the other kept for roaster production Sometimes both sexes are sold as roasters In these cases the males are marketed much sooner than the females When the sexes are not separated at hatching, and the males and females are raised together, there will be a vast difference in the weights of the two sexes at market time, such a program is to be discouraged See Tables 20 6 and 20 7

Managing Roaster Production

Continue with the broiler management program There are few changes except for the following

(1) *More floor space required* Floor space requirements are given in Table 20 3 Optimum growth will not be possible unless the birds have plenty of room Too often a quick decision is made to carry a group of broilers to roaster weight without providing additional floor space In such cases, some of the birds should be marketed as broilers, thus providing more space for those kept as roasters

(2) *More feeder and waterer space needed* Roasters are larger, they require more room to eat and drink Provide 4 in (10 2 cm) of feeder space and 2 in (5 1 cm) of waterer space after 8 weeks of age

(3) *More ventilation* When the movement of air through a poultry house is based on the weight of birds in the house, the recommendations given previously are satisfactory It is only when the roasters are crowded, that difficulties with ventilation occur See Table 20 2

(4) *Adequate feed consumption important* Appetites begin to wane in heavier growing chickens Adequate feed consumption is a must if roaster gains are to be produced economically *Many producers resort* to continuous light to induce the birds to eat both night and day

High Incidence of Breast Blisters

One of the greatest difficulties with roaster production is associated with the high incidence of breast blisters Heavy birds seem to sit more than lighter birds Males sit more than females The incidence of breast blisters therefore, is related to body weight, sex, and the material with which the breastbone comes in contact

The economic loss from breast blisters in roasters is tremendous The blisters must be cut out at processing time and this downgrades the carcass In the case of dressed broilers with breast blisters, the bird may be cut into parts and only the breast is downgraded However, roasters are sold as whole body birds, removing the breast blister at processing time downgrades the entire carcass

Remedies for breast blisters There is no method whereby all breast blisters may be eliminated, management must resort to a program of reducing their incidence to a minimum Some ways of making the reduction are

(1) Use of females instead of males Even though the growing period of the females will be longer than in the case of males, reduction in the

incidence of blisters usually will offset the costs of the longer growing period.

(2) Keep the litter dry. Wet litter produces more and larger blisters.
(3) Keep a deeper litter. When the litter becomes thin and hard, the difficulty from blisters increases.
(4) Feed more often. When birds are eating, they are not sitting, and the breast is in contact with the litter for a shorter period.
(5) Stir the birds occasionally. This keeps the birds moving rather than sitting.
(6) Use a ration especially formulated for roaster production.

Cost of Producing Heavier Weights

Feed is the main item of cost of producing 1 lb of roaster. The relationship between weight and feed cost is shown in Table 20.18. Sex is also a factor, not only because females must be kept for a longer period than males to attain a desired live weight, but because females are poor converters of feed to meat compared with males. Thus 1 lb of live female roaster is more expensive to produce than 1 lb of live male roaster.

TABLE 20.18

AGE AND SEX AS THEY AFFECT THE FEED COST PER POUND OF GAIN
(In U.S. Dollars)

Age of Bird Wk	Males		Females		Straight-run	
	Feed Conversion to Date*	Feed Cost per Pound to Date**	Feed Conversion to Date*	Feed Cost per Pound to Date**	Feed Conversion to Date*	Feed Cost per Pound to Date**
8	2.06	$0.087	2.14	$0.090	2.10	$0.088
9	2.16	0.091	2.26	0.095	2.21	0.093
10	2.27	0.095	2.39	0.100	2.32	0.097
11	2.38	0.100	2.52	0.106	2.44	0.103
12	2.49	0.105	2.68	0.113	2.57	0.108
13			2.86	0.120	2.71	0.114
14			3.06	0.129		
15			3.29	0.138		
16			3.55	0.149		

*Units of feed per unit of weight.
**Based on feed cost of $0.042 per lb ($0.092/kg).

Feeding Roasters

The ultimate of economical feeding lies with specialized rations for larger birds. Such birds have large skeletons at this age; the basic nutritional requirement is for the deposition of large amounts of flesh and fat. This may be met with feeds that have lower protein and higher energy. These rations are lower in price than those used for the production of broilers and are discussed in Chapter 37.

SURGICAL CAPONS

A cockerel may be grown to weights greater than those attained by broilers or roasters if it is surgically caponized. Caponizing, the surgical castration of male

chickens, produces a unique type of poultry meat It is claimed that the meat is more tender, juicier, and more flavorful

Capon Weights

Most capons are marketed at an eviscerated weight of 8 to 10 lb (3 63-4 54 kg) Producers feel that growing them to these weight levels removes them from competition with roaster chickens and places them in a special category The length of the growing period necessary to attain such weights is from 20 to 24 weeks Actually, capons grow no faster or to larger weights than noncaponized males, but the quality of the meat is far superior

Age to Caponize

Male birds are caponized at 2 to 4 weeks of age, which is much younger than in the past A single incision is made on one side of the bird and both testicles removed from the one opening A good caponizer can operate on about 200 birds per hour An antibiotic is injected into the birds at the time of caponization, or one is fed for a week prior to the operation and for a week after This aids in preventing stresses

Feeding Program

Cockerels are starved for one day prior to castration to reduce the size of the intestines Usually a feed that will not produce the most rapid growth is used where breast blisters and crooked keels are a problem However, in most instances rapid growth is desirable A deep yellow carcass color is necessary, and diets are altered during the last two months of the growing period to induce the necessary yellow pigment

Poultry Genetics

Genetics is the science devoted to the study of inheritance. That "like begets like," or that offspring tend to resemble their parents, is the basis for the subject of this science. However, the theory is far from accurate. Although offspring do resemble their parents in some respects, in others they do not. The geneticist has worked out a great many rules governing the inheritance of certain characters pertaining to the chicken, and he is constantly using these to improve present strains of chickens and to develop new lines. In many cases the subject of genetics has been enlarged to include those principles associated with the behavior of birds and flocks. Such things as population distribution, physical control of the gene potential, hormones, management, physiology, and many others are now included in a study of poultry breeding.

The poultryman is required to leave the development of new lines of chickens to the scientifically trained geneticist, but he is interested in those genetic and closely related factors that are his responsibility and must become a part of his management program. This chapter will deal with genetic laws so that the poultryman will better understand the practical applications of genetics set forth in Chapter 22, GENETIC MANAGEMENT. The discussion in this chapter is strictly diagrammatic and elementary. It would be impossible to include a full discussion of the subject of genetics in a text of this type. For those who wish to pursue the matter further, a textbook should be consulted.

THE CELL

The cell represents the basic constituent of all living material. Some living things are composed of but one cell, while others may be made up of millions. Not only does the number vary, but the cell size may range from a tiny microscopic unit, as in most cases, to large cells as found in egg yolk.

Parts of the Cell

The cell has three basic parts:

(1) *Cell wall*. This holds the interior contents of the cell together, and prevents the contents of one cell from mixing with the contents of another.

(2) *Cytoplasm*. When a cell is stained for microscopic examination, a portion of the interior takes on a light color. This is the cytoplasm, which lies outside the nucleus.

(3) *Nucleus*. The area of the cell that stains dark is the nucleus. It is essential to many functions of the cell, and to the transmission of hereditary factors.

Types of Cells

Cells of chickens may be classified according to their function within the body.

(1) *Somatic cells*. These are the cells that compose the tissues of the body, and are to be differentiated from the sex cells.

(2) *Sex cells* These cells are specialized in that they are responsible for the continuation of the species Somatic cells are not capable of creating new individual offspring, this is accomplished by the union of a female sex cell with a male sex cell When the individual dies, the somatic cells die, the sex cells, if united, remain on to perpetuate the parents Thus, it might be said that "sex cells never die," and the theory is correct at least for those sex cells involved with the creation of the new individual

CHROMOSOMES AND GENES

Within the nucleus of the cell are rod like structures known as chromosomes Their number varies according to the species from two in certain lower forms of life to dozens in the higher forms Although subject to some variation, it may be stated that the number of chromosomes remains the same, generation after generation Chromosomes stain dark, and in most instances can be easily seen under a microscope

Chromosome number in the chicken Being small and of varying shapes and sizes, chromosomes in the nucleus are difficult to count This is especially true in the case of the chicken Some scientists have placed the number as low as twelve, while others feel there may be as many as seventy eight chromosomes in the nucleus

Chromosomes in pairs In the *resting body cell*, chromosomes are normally found in pairs That is, although the shape and size of each set of chromosomes vary, they occur in pairs, the two members of which are alike in length, diameter, and shape During certain phases of cellular division, members of each pair align themselves together in the center of the nucleus In these stages the paired duplication may easily be seen through a microscope At other stages, the pairs dissociate, and each member is intermingled at random with chromosomes of other pairs in the nucleus

Types of chromosomes There are two types of chromosomes and at least a portion of their function is different

(1) *Autosomes* All but one pair of the chromosomes in the body cells are known as autosomes The one pair represents the sex chromosomes

(2) *Sex chromosomes* In the somatic cell, *one pair of chromosomes is* in part different from the other pairs The chromosomes of this pair are known as the sex chromosomes, as they are associated with the determination of the sex of the individual

The Genes

Within the chromosomes certain units of material are to be found that are partially responsible for the hereditary transmission of characters that differentiate one part of the body from another, and one species from another These units are known as *genes* With proper cell staining, many genes may be seen under a high powered microscope They seem to be like discs or bands within the chromosomes Genes are thought to be made up of chemicals which produce certain reactions and cause the cells to manifest themselves differently and to

produce the various parts of the body and many of the body's different physiological potentialities

Location of the genes within the chromosome Identical genes are located in each of a pair of chromosomes Furthermore, each specific gene is always at the same place in the chromosome Thus, when two *allelomorphic* (like) chromosomes pair up in the cell, a specific gene in one chromosome will be exactly opposite the same gene in the other chromosome of the pair

The gene characters Each gene is responsible for a certain physical or physiological character For example, one of the genes on one of the autosomes is responsible for the production of a rose comb in chickens This gene is always in the same chromosome and at the same location within the chromosome We might go on and on, for geneticists have established the existence of genes responsible for many characters in the chicken A great many genes have been identified as to the chromosome in which they are located Furthermore, the *locus* (location) of many genes within the chromosomes has been determined Drawings have been made of these chromosomes showing the location of the genes These are known as *gene maps* As more information is brought to light, the gene maps are increased in scope

Maintenance of Chromosome Number in Somatic Cells

One of the accomplishments of nature is the ability of the somatic cells to divide and form two similar cells, thus giving rise to growth and differentiation of cell material Furthermore, each new *daughter* cell has exactly the same number of chromosomes as its parent, thus continuing the basic relationship How this is accomplished is interesting Just before the parent cell divides to form 2 *daughter* cells, the number of chromosomes doubles, so there are 2 members of each of a pair where there was but 1 pair before When the cell divides, each *daughter* cell gets one full set of chromosomes and the number remains intact, division after division

Certain cells arise within the male and female that give rise to the sperm cell or the egg cell In the case of these formations, the chromosomes do not double just before division, as in the case of somatic cellular multiplication, but rather, 1 member of each pair of chromosomes goes to each of the 2 new cells, the *gametes* Thus, all egg or sperm cells have only half the number of chromosomes as the somatic cells, but there is always 1 member of each pair of chromosomes present This phenomenon is known as the *reduction division* of the chromosomes of the cell A new individual can only be the result of an egg cell uniting with a sperm cell, the *zygote* Upon its formation, the single cell again has a full component of chromosomes, half coming from the dam and half from the sire, and the total number of chromosomes is restored Furthermore, there are two members of each pair There is continuity of the germ plasm

Dominant and Recessive Genes

Rose comb has been designated above as being the result of a specific gene, this gene has a definite location on one of the *autosomal* chromosomes A complete list of other known similar genes could be given But genes have not always re-

mained intact through the centuries, nor are they constant today The substance responsible for their expression is subject to chemical reaction, even though such a reaction is exceptionally rare under natural conditions It may occur only once in several centuries When such a reaction occurs the gene material is changed, and the new material in the form of a new gene is passed on to coming generations These changes are known as *mutations*, and by definition mean that the differences were sudden Although nature has provided that all forms of life be subject to mutations in order to give rise to new and different features which could in turn, produce new species, mutations may be easily produced in some forms of life by artificial means, e g , chemicals, X rays, etc

Many natural mutations produce only a slight change in the individual, but others show such a strong effect that the entire structure associated with the gene is altered Such a case is found with rose comb In this case, the gene change through mutation produced a single comb Thus, there is now one gene at a certain locus on the chromosome that produces rose comb, another that produces single comb These are known as *allelomorphic genes* or *alleles*

Centuries ago, and for centuries after the mutation took place, many chickens carried genes for rose comb and single comb, but each individual had either a rose comb or a single comb It could not, and does not today, have both Modern poultry breeders, through a process of genetic selection and testing, have been able to eliminate the gene not wanted and develop a pure line of either rose comb or single-comb birds

Dominant When one bird has genes for both rose comb and single comb, the bird will have a rose comb Thus, the rose-comb gene is *dominant* to the gene for single comb Although the expression produces a rose comb, the single-comb gene is still there, only the rose comb is capable of manifesting itself

Recessive The single-comb gene is said to be *recessive* to the gene for rose comb Or more simply, rose comb is dominant to single comb, single comb is recessive to rose comb

Some dominant and their allelomorphic recessive genes Many pairs of genes have been discovered by geneticists, and their dominance or recessiveness determined Some common ones are as follows

Character	Dominant or recessive
rose comb	dominant to single comb
barred plumage	dominant to nonbarred plumage
silver plumage	dominant to gold plumage
slow feathering	dominant to fast feathering
side sprigs	dominant to normal comb
broodiness	dominant to nonbroodiness
white skin	dominant to yellow skin
feathered shanks	dominant to nonfeathered shanks

Phenotypic and Genotypic Relationship

From the above it may be seen that all rose-comb chickens may not be alike Some could be pure for rose comb, having two genes for the character, one in each of the pair of chromosomes, yet another could be impure, having a gene for rose comb in one member of the pair, a gene for single comb in the other When

the bird has a rose comb, rose comb is its *phenotypic* expression; its gene makeup is its *genotypic* expression.

Homozygous genotype: When the two genes in a pair of chromosomes are identical, either rose or single, the genotype is *homozygous* (like). Thus, there could be a bird homozygous for rose comb or one homozygous for single comb. When the genes are the dominant ones, the bird is *homozygous dominant.* When the genes are the recessive ones, the bird is a *homozygous recessive.*

Heterozygous genotype: When one chromosome member of a pair carries a gene for rose comb and the other chromosome contains a gene for single comb, the genotype is said to be *heterozygous* (unlike).

Genetic Symbols

Rather than continue to write out a full description of each gene, like rose comb and single comb, geneticists have designated an abbreviation for each gene. For instance, the abbreviation or symbol for the dominant rose-comb gene is R. So as to correlate its allelomorph, the gene for recessive single comb is r. This procedure of abbreviations is similarly followed for all allelomorphic pairs of genes. Some symbols and their phenotypic and genotypic expressions for rose and single comb are shown below:

Type of bird	Symbolic Expression	Genotype	Phenotype
Homozygous dominant for rose comb	RR	Homozygous rose	Rose comb
Homozygous recessive for single comb	rr	Homozygous single	Single comb
Heterozygous for rose comb	Rr	Heterozygous rose	Rose comb

The Sex Chromosomes

The one pair of sex chromosomes in each cell of higher forms of life is different in one respect: the sex chromosomes are responsible for the sex of the individual. In the male chicken, each member of the pair of sex chromosomes is fully developed and functional inasmuch as it contains genes. In the female, however, only one member of the pair is functional; the other has atrophied and for all practical purposes contains no genes. When two sperm cells are formed from one complete cell, each sperm cell gets one member of the pair of sex chromosomes. But when an egg cell is formed by the female, only half such cells will receive a fully developed sex chromosome, the other half containing an atrophied one. When the sperm cell unites with an egg cell to form a new organism, the zygote will receive one fully developed sex chromosome from its male parent. However, half the zygotes will receive a fully developed sex chromosome from the female parent; the other half will receive an atrophied one. In this manner, those zygotes containing two fully developed sex chromosomes are destined to become males; those receiving one fully developed sex chromosome and one atrophied one will become females. This is the genetic interpretation of the inheritance of sex.

X and Y chromosomes: Geneticists have named the fully developed sex

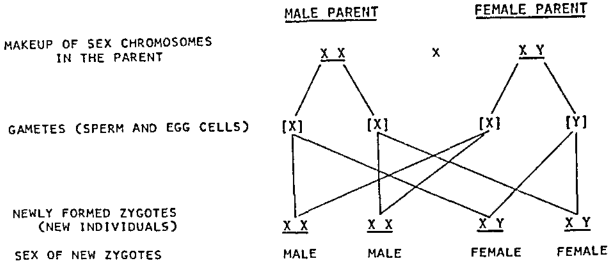


FIG 21 1 INHERITANCE OF SEX

chromosome the X chromosome; the atrophied one, the Y chromosome. A simple example showing the inheritance of sex is given in Fig 21.1.

Interpretation From Fig. 21.1 it may be seen that each male gamete (sperm cell) has an equal chance of uniting with each of the two types of female gametes (egg cells). This relationship gives rise to the production of half males and half females in the next generation.

INHERITANCE OF ONE PAIR OF CHARACTERS

It has been shown that there can be a pure rose-comb individual, *RR*, and a pure single comb individual, *rr* Each will breed true because the germ material continues intact, there is no chance for the opposite allelomorphic gene, [R] or [r] to enter the picture But what happens when a rose-comb bird, male or female, is mated with a single-comb bird, male or female? Fig 21 2 shows the gene makeup and the gene inheritance.

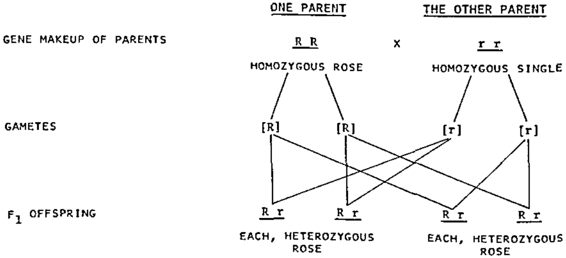


FIG 21.2 INHERITANCE OF ONE PAIR OF CHARACTERS

Explanation A homozygous rose comb parent, *RR*, produces two like gametes, [R] and [R] A homozygous single-comb parent, *rr*, produces two like gametes, [r] and [r] Each of the two male gametes has an equal chance of uniting with each of the two female gametes, initiating four combinations in the F_1 (first filial generation), *Rr*, *Rr*, *Rr*, and *Rr* All are identical, genotypically they are heterozygous for rose comb, phenotypically, all have rose combs

Note The gene for rose comb, and its allele for single comb are located on one of the autosomes rather than on one of the sex chromosomes Therefore, there is no involvement with the sex of the individual

Dominance Complete

In the case of rose and single comb, the gene for rose is *completely dominant*, that is, the comb on a heterozygous rose comb bird, *Rr*, looks exactly like the comb on a homozygous rose-comb bird, *RR*

Crossing Two Heterozygous Parents

If two heterozygous rose comb birds, *Rr* (as the F_1 individuals from Fig 21 2), are mated together, the inheritance follows the pattern in Fig 21 3

Explanation A heterozygous rose comb bird produces two types of gametes, [R] and [r], in equal numbers Each gamete from one sex has an equal chance of combining with each gamete from the other sex to give rise to four possibilities in the F_2 generation (Note *rR* combinations are always written with the dominant gene foremost, as *Rr*)

F_2 *Ratio Expression* The F_2 offspring in Fig 21 3 may be expressed as two different ratios

Phenotypic ratio

3 rose 1 single

Genotypic ratio

1 homozygous rose, *RR* 2 heterozygous rose, *Rr* 1 homozygous single, *rr*

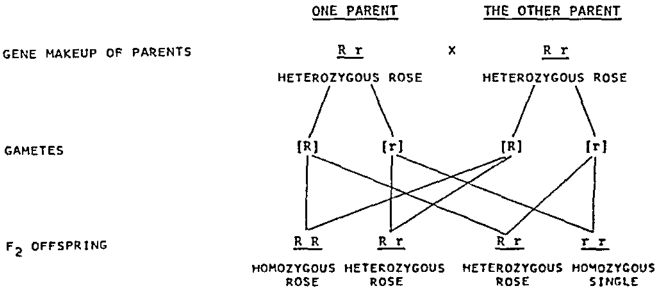


FIG 21 3 INHERITANCE WHEN TWO HETROZYGOUS PARENTS ARE CROSSED

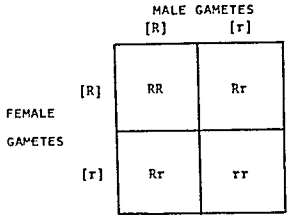


FIG 21 4 GRID SHOWING F_1 GAMETIC COMBINATIONS

Another method of diagramming combinations To show more clearly the various combination of the genes when two parents are crossed, a gene combination grid may be used, as shown in Fig 21 4

Explanation In Fig 21 3, the gametes from each sex are [R] and [r] In Fig 21 4, the male gametes, [R] and [r], are placed at the top of the grid, the female gametes on the left-hand side (*Note* The male and female gametes are always placed in these locations) Using the grid to cross multiply, the various F_2 combinations appear in the squares

Crossing Heterozygous and Homozygous Recessive Individuals

If a heterozygous rose-comb bird, *Rr*, is crossed with a homozygous recessive single-comb bird, *rr*, the genetic interpretation of the cross is shown in Fig 21 5

Explanation The heterozygous rose-comb bird produces two kinds of gametes, [R] and [r], but the homozygous single-comb bird produces only [r] gametes or sex cells The gametic combinations in the offspring

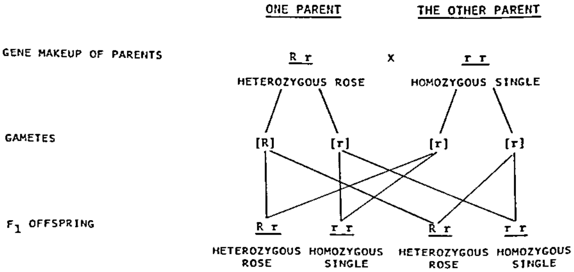


FIG 21.5 INHERITANCE WHEN A HETEROZYGOUS ROSE-COMB BIRD IS CROSSED WITH A HOMOZYGOUS SINGLE-COMB BIRD

show the following ratios

Phenotypic ratio

1 rose 1 single

Genotypic ratio

1 heterozygous rose, *Rr* 1 homozygous single, *rr*

Backcross When an F_1 individual is crossed "back" to a homozygous recessive bird, the cross is known as a *backcross* The procedure is used by geneticists to test the purity (homozygosity or heterozygosity) of a bird for a given character An example is as follows

Problem A group of female chickens has rose combs, but the strain is not pure for rose comb inasmuch as single comb birds appear occasionally To determine which females are pure (homozygous *RR*) for rose comb they are mated with single comb (homozygous recessive, *rr*) males, the females trap nested, and the chicks from each dam hatched in separate containers

Solution In the above problem there are two types of rose comb breeder females, *RR* and *Rr*, the former being pure, the latter, impure When *RR* females are mated with *rr* males all the offspring will have rose combs, and will be heterozygous, *Rr*

When *Rr* females are mated with *rr* males, half of the offspring chicks will have rose combs, *Rr*, and half will have single combs, *rr* This group of breeder females is to be discarded because they are not pure for rose comb

INHERITANCE OF TWO PAIRS OF CHARACTERS

Another somatic gene is known to produce black feathers, its symbol is *B* Its recessive, *b*, is responsible for white feathers in one type of bird with white plumage, known as recessive white The pattern of inheritance of these genes is exactly the same as in the case of rose and single comb However, the genes *B* and *b* are on a pair of somatic chromosomes different from the pair containing the *R* and *r* genes

Genes Considered Singly

We have seen what happens when *RR* birds are mated with *rr* birds If we consider only the genes associated with *BB* (homozygous black) birds and *bb* (homozygous white), when a black chicken is mated with a white chicken all the offspring are heterozygous black, *Bb* Crossing two F_1 individuals produces chicks in the phenotypic ratio of three blacks to one white Genotypically, there is a ratio of one homozygous black, *BB*, to two heterozygous blacks, *Bb*, to one homozygous white, *bb*

In other words, when we consider comb type and black color singly, the regular ratios for one set of characters appear in the F_2 generation But what happens when both pairs of characters are considered together?

The Principle of Independent Assortment

When two pairs of characters are involved, each on different pairs of chromosomes, there are several more combinations of genes in the gametes This increase in number is simply the result of mathematical chance, inasmuch as the chromo

somes independent of one another align themselves on the spindle just before the reduction division

How independent assortment works For simplicity's sake, let us suppose there are but two pairs of autosomes in the chicken, "A" and "B". The two members of the pair of "A" chromosomes could be designated, "A_1" and "A_2". Similarly, "B_1" and "B_2" for the "B" pair. When the cell division takes place to form the two sex cells, the chromosomes within each pair align themselves on the spindle at random. One possibility is

$$\begin{bmatrix} A_1 \\ B_1 \end{bmatrix} \begin{bmatrix} A_2 \\ B_2 \end{bmatrix}$$

In the above case, chromosomes "A_1" and "B_1" go to form one gamete, "A_2" and "B_2" would go to the other. But there is one more alternative for alignment on the spindle when two pairs of chromosomes are involved

$$\begin{bmatrix} A_1 \\ B_2 \end{bmatrix} \begin{bmatrix} A_2 \\ B_1 \end{bmatrix}$$

When this alignment occurs, one gamete contains chromosomes "A_1" and "B_2", while the other contains "A_2" and "B_1". The alignment of the chromosomes in respect to each other is due to chance alone; therefore, in one half of the cell reduction divisions the first example would hold true, and one half would occur as in the second example. Male and female gametes (sex cells) would now contain four combinations of the "A" and "B" chromosomes as follows

$$[A_1\ B_1]$$
$$[A_2\ B_2]$$
$$[A_1\ B_2]$$
$$[A_2\ B_1]$$

Genes on the Chromosomes

For a discussion of the inheritance of two pairs of genes we can assume that the gene for rose comb, R, and its allelomorph, the gene for single comb, r, are located on the "A" chromosome The gene for black plumage, B, and its allelomorph for white plumage, b, are on the "B" chromosome A homozygous rose-comb and colored fowl would contain all dominant genes, RR and BB A homozygous recessive single-comb and white bird would be described as rr and bb More commonly these are written $RR\ BB$ and $rr\ bb$

Crossing a Rose, Black and a Single, White Bird

The outcome of this cross is shown in Fig 21 6

Explanation One parent produces only [RB] gametes, the other only [rb] gametes Thus, the only offspring combination that could occur in the F_1 would be $Rr\ Bb$, or heterozygous rose and heterozygous black birds Phenotypically, all offspring would have rose combs and black plumage

Cross Involving Two Heterozygous Individuals

If two F_1 individuals from Fig 21 6 are crossed together, each parent produces four types of gametes, since there is independent assortment of the chromosomes in which the genes rest The cross is shown in Fig 21 7

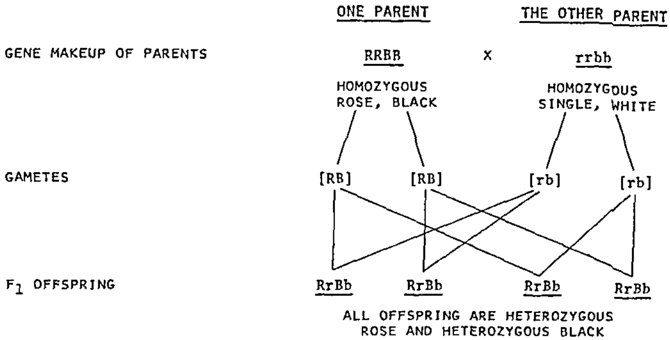


FIG. 21 6. INHERITANCE OF TWO PAIRS OF CHARACTERS

Explanation: Since each F_1 parent in Fig. 21.7 produces 4 types of gametes, and each produced by the male parent has an equal chance of uniting with each of the four different gametes produced by the female, there would be 16 different combinations as shown in the F_2 grid in Fig. 21.8. The F_2 ratios expressed are as follows:

Phenotypic ratio

9 rose, black: 3 rose, white: 3 single, black: 1 single, white

Genotypic ratio

By checking against the genotypes in the grid in Fig. 21.8, the combinations produce a ratio that is 1:2:1:2:4:2:1:2:1. Each of the groups in this ratio would be genetically different.

Of every 16 birds produced in the F_2 generation, on the average there will be 12 with rose combs and 4 with single combs, or a 3:1 ratio. There

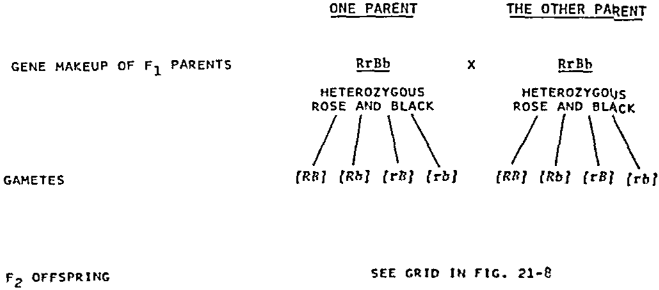


FIG. 21.7. INHERITANCE OF TWO PAIRS OF CHARACTERS WHEN PARENTS ARE HETEROZYGOUS

MALE GAMETES

FEMALE GAMETES	[RB]	[Rb]	[rB]	[rb]
[RB]	RRBB	RRBb	RrBB	RrBb
[Rb]	RRBb	RRbb	RrBb	Rrbb
[rB]	RrBB	RrBb	rrBB	rrBb
[rb]	RrBb	Rrbb	rrBb	rrbb

FIG 21 8 F_1 GAMETIC COMBINATIONS WHEN EACH PARENT IS HETEROZYGOUS FOR TWO CHARACTERS

will be 12 blacks to 4 whites, or a 3 1 ratio Considering the 12 with rose combs, 9 would be black and 3 white, or a 3 1 ratio Of the 4 with single combs, 3 will be black and 1 white, or a 3 1 ratio There will be 4 whites, 3 will have rose combs and 1 a single, or a 3 1 ratio

SEX LINKED INHERITANCE

The illustrations given for gene inheritance thus far have considered only those genes borne on the autosomes There also are genes on the sex chromosomes, and the fact that the male has two sex chromosomes and the female but one complicates the diagrammatic picture of inheritance of these genes

Inheritance of Genes on the Sex Chromosomes

One dominant gene found on the sex chromosomes produces silver (a certain type of white) feather color Its symbol is "S" The recessive allelomorph is "s", the factor for gold feather color

As the male nucleus carries two sex chromosomes, there will always be either an [S] gene or an [s] gene in each sex chromosome If there were two [S] genes in the pair of chromosomes of the male, the bird would be *SS*, or homozygous silver An *ss* makeup would represent homozygous gold An *Ss* combination would be heterozygous silver However, the female nucleus contains but one viable sex chromosome with its component of genes The "Y" chromosome in the female does not carry genes and is involved with inheritance only as its presence produces a female zygote Therefore, the female nucleus carries but one sex chromosome which could carry either *one* [S] or *one* [s] gene It would be *hemizygous*

Those genes located on the sex chromosomes are known as sex *linked genes*,

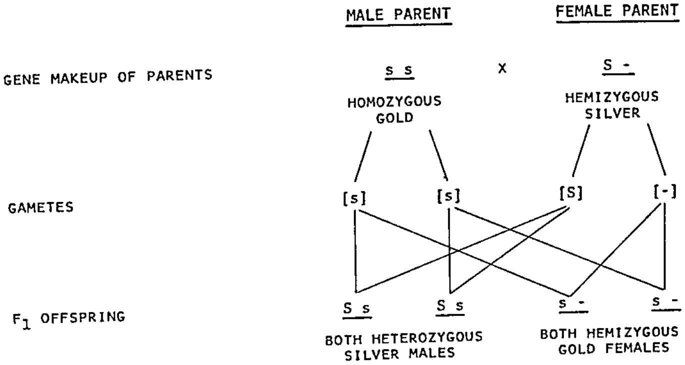


FIG. 21.9. INHERITANCE WHEN A GOLD MALE IS CROSSED WITH A SILVER FEMALE

that is to say, such genes are linked with the sex chromosomes. The inheritance of one such pair of sex-linked genes is shown in Fig. 21.9. It involves a cross between a gold male and a silver female.

Explanation: In Fig. 21.9, the male has 2 functional sex chromosomes with a gene for gold plumage, [s], on each, while the female has but 1 functional chromosome with a gene for silver plumage, [S], on it. The female also has one nonfunctional chromosome carrying no genes, which for clarity has been designated [-]. In the F_1 generation, notice that when 2 genes appear (which would represent 2 "X" chromosomes), the sex is male. When only 1 gene appears, there is but 1 "X" chromosome and the sex is female.

Crisscross inheritance: In Fig. 21.9, notice that a gold male and a silver female are used for the parents; yet the offspring chicks are silver males and gold females. This is sometimes known as *crisscross inheritance*, because the dominant and recessive characters crisscross in a diagram of this sort. In other words, male chicks have the same color as their female parent; female chicks have the same color as their male parent.

Practical example of this cross: The cross illustrated in Fig. 21.9 is used by many breeders to provide a method of sexing the day-old chicks by down color. By mating a Rhode Island Red (or any other red, gold, or buff) male with a Barred Rock (or any other silver female), the male and female day-old, offspring chicks will be a different color, making it easy to sex them.

Reciprocal Cross Does Not Produce Sex Linkage

If a silver male is mated with a gold female, both the male and female offspring chicks receive a gene for silver, [S], from the sire, and all chicks will be silver. There is no possibility of sorting them by color to segregate the males from the females.

Important To make a practical sex-linked mating in order to sex the day-old chicks, the male parent must be homozygous for the recessive factor and the female parent must show the dominant factor. The reciprocal of this cross will not work

INHERITANCE OF QUANTITATIVE CHARACTERS

The genetic characters described in the above paragraphs have been completely dominant or recessive They may be spoken of as *qualitative characters*, and there are many But all dominant characters do not show complete dominance In some instances the recessive character bears as much weight as the dominant factor In these cases there is a happy medium in the offspring For example, when a large chicken is crossed with a small chicken, the offspring chicks will have a weight approximately midway between the weights of the two parents Such genetic factors are known as *quantitative characters* Probably the large proportion of genes in poultry are in this category Egg size, egg production, skeleton size, egg shape, shell color, and breast width are but a few of the many quantitative characters

Improvement in a Quantitative Character

There are often several quantitative characters working together to induce a change in the genetic makeup of a line of chickens Egg production is in this group, for several sets of genes are responsible for the production of a large number of eggs

How strain improvement is made When the number of homozygous genes responsible for a given trait, such as egg production increases, the number of eggs a bird lays also increases Theoretically at least, the birds within a flock that lay the best would be the most homozygous for the gene factors responsible for egg production Thus, mating together only the best producing birds would tend to increase the number of dominant genes within the line And this is the procedure the geneticist uses to make improvements He continues *to breed from the best individuals*, generation after generation, in order to increase the homozygosity of the gene material in his strain

Genetic Management

Genetics is a science used mainly by the technician who develops new and better strains of chickens But flock management plays an important part in the response to genetic development Only the geneticist who has an insight into the behavior of genes under different environmental and other conditions will be able to make the greatest improvement in his lines of birds For instance, a poultry breeder could develop a strain of broilers that would grow well on a litter floor but would do poorly on a wire floor To be a practical genetic breeder he would have to develop a line of birds especially suited to wire floors

But the geneticist can do only a part of the job Generally speaking, management has more to do with flock improvement than genetics Although each line of birds has a bred in potential to do a certain job, it is up to the poultryman to manage the flock so that the birds will have full expression of their potential

This chapter is designed to give the practical poultry raiser a better insight into some of the reasoning behind genetic developments, why they have been instigated, and how he can best reap all the benefits of this science

SOME AUTOSOMAL CHARACTERS

Besides rose and single comb, and black and recessive white, there are some other autosomal characters that have practical application in poultry production

Dominant White Plumage Color

Most meat type male lines of broiler breeder parents are classified as dominant white When such males are crossed with females that have colored feathers, the offspring chicks are white or nearly white (On occasion there may be some black or red showing) This phenomenon is due to an autosomal gene that inhibits the production of color in the feathers The White Leghorn is the only pure breed with white feathers in this classification Actually, the White Leghorn is a colored bird with an *inhibitor gene* that prevents expression of the genes for colored feathers Dominant white meat type male lines in use today are synthetics, most of them were developed by incorporating the inhibitor gene from the White Leghorn, then purifying the line

The inhibitor gene is dominant and symbolized as "I" Its recessive allele enables genes for colored feathers to produce their effects Its symbol is "i" The "I" gene is also only partially qualitative That is, a homozygous bird for the inhibitor, *II*, will completely suppress colored feathers, but this is not always true in the case of a heterozygous bird, *Ii*

If a dominant white male, *II CC* (homozygous for the inhibitor and color), is crossed with a colored female, *ii CC*, all the offspring will show the genotypic makeup, *Ii CC* Such offspring would be white or nearly white Continual selection within the dominant white male line would eliminate practically all the slightly colored offspring

The above cross is indicative of what happens when a dominant white, meat type male line is crossed with certain colored female lines to produce broiler chicks

There are, however, certain white female lines that are used for broiler production These are known as recessive whites, as indicated below

Recessive White Plumage

A great many White Plymouth Rocks have been used for the female side of the mating in the production of broiler chicks Such birds are genetically known as a *recessive white* They have neither an inhibitor gene, "I", nor a gene for feather color, "C" Their genotypic makeup is *ii cc* When such a bird is crossed with a dominant white male, *II CC*, all the offspring broiler chicks are *Ii Cc*, or heterozygous for both characters For all practical purposes they would be white, but on occasion some black or brown color will show in the outer feathers

In some dominant white male lines the gene for colored feathers, "C", has been nearly eliminated by constant selection When the "C" gene is removed, such birds have a genotypic combination of *II cc* When crossed with a recessive white female, *ii cc*, all offspring broiler chicks are *Ii cc*, and completely white

White-skin Chickens

In some countries broilers with white skin are preferred to those with yellow skin Special meat type males with white skin are crossed with meat type females having yellow skin, as white skin is dominant to yellow skin, and the broiler offspring have white skin This procedure enables the producer of such chicks to use present-day, meat type females with the special males, avoiding developing a white skin female line as well as a white-skin male line

Consumer demand for skin color In the United States and some other countries there is a consumer demand for whole body or cut up broilers with a deep yellow skin color But such a chicken, processed normally in water of relatively low temperature, is unsuited for the "take-out" restaurants The batter used to coat the chicken pieces prior to cooking in deep fat does not adhere to the outer skin, and tends to flake off after cooking If the water temperature is raised at processing time the batter tends to stick much better, but this bleaches out more of the yellow color in the skin However, the whitish appearance of the parts is no detriment to the take-out restaurant trade, in fact, it is demanded

HERITABILITY OF QUANTITATIVE CHARACTERS

Quantitative genetic characters do not have a concise expression of their dominance or recessiveness, as in the case of qualitative characters such as rose comb and single comb For instance, egg production per hen varies between 350 and 100 eggs or less per year When a high producing strain is crossed with a low producing strain, the offspring produce eggs at some rate between the two parent strains Because quantitative characters are expressed as the result of several genes working together, there is no possibility of making simple genetic crosses to improve the occurrence of any desired trait

Heritability of Quantitative Characters

Constant selection, generation after generation, and breeding from only the better birds is the most common method of improving the exemplification of characters that are quantitative in nature Even then improvement in each charac

ter is not the same; in some instances there can be great accomplishments in the next generation, in other cases, they can be small. Another method of making genetic improvement is to cross two or more closely inbred lines of chickens, each line possessing great homozygosity for the desired characters. If the lines nick, improvement may be great for certain characters.

The ability of quantitative characters to be transmitted from parent to offspring is known as *heritability*. Each character, being quantitative, varies in its ability to be transmitted as compared to other characters. When heritability is high, progeny improvements are rapid, but when it is low, progress in improving future generations is slow.

Heritability percentages It is common for the heritability of quantitative characters to be expressed in terms of percent. Many geneticists have tried to determine these percentages, but the results have been highly variable because of the varying conditions under which the chickens involved have been housed and kept. A composite average of some of these results is given in Table 22.1

TABLE 22 1

SOME ESTIMATED HERITABILITY PERCENTAGES

Character	Heritability Percentage
8 Week broiler weight	45
Adult body weight	55
Egg production	25
Chick livability	5
Adult livability	10
Egg weight	55
Age at sexual maturity	25
Keel length	20
Body depth	25
Fertility	5
Hatchability of fertile eggs	15
Shell thickness	25
Egg shape	40
Albumen quality	25
Blood spots	15
Breast fleshing	30

Example· One would expect to be able to make a greater improvement in broiler weight than in egg production by continually breeding from the better birds, generation after generation. Hatchability, with only 15% heritability, could be improved very slowly under similar methods of selection.

Importance of management· The difference between the heritability percentages and 100% is attributable to management. For instance, only 5% of results of good chick livability are due to genetics, 95% are the responsibility of management. As with the other quantitative characters given in Table 22.1, there is a relationship between genetics and management.

Nickability

As many genes are responsible for the expression of quantitative characters, it is possible to develop a line of chickens that is quite homozygous for several dominant genes Another line might be homozygous for dominant factors other than those of the first line When the two lines are crossed, new dominant genes are brought together in the offspring, and the parent lines are said to *nick* Actually, this means that the offspring will be better than either of the parent lines in respect to a certain character However, other characters in the same lines may show little or no nickability An example when two parent meat type lines were crossed is shown in Table 22 2

Explanation In Table 22 2, there is a definite nicking of characters responsible for egg production, as the offspring laid more eggs than either of the parent lines However, this was not true of egg weight

TABLE 22.2

OFFSPRING PRODUCTIVITY AS COMPARED WITH THEIR PARENTS

Item	Parent Male Line	Parent Female Line	Offspring
Total eggs hen day	148	165	166
Total eggs hen-housed	139	155	156
Total hatching eggs	121	134	139
Average egg weight (oz/doz)	25 7	25 4	25 4
Average egg weight (gm/ea)	*60 7*	*60 0*	*60 0*

Management Affects Expression of Gene Makeup

All quantitative genes do not express themselves equally under all systems of management A typical example occurs in the case of egg production where a line of egg type layers would lay an average of 240 eggs each when kept on a littered floor, but would produce only 228 eggs when kept in cages Similarly, birds might produce well when given a good feed but poorly when given an inferior feed With *qualitative* characters, the expression of the genes is complete regardless of the management For instance, birds have either a rose or single comb, there is no variation

Getting the genetic potential All strains of chickens have a bred in inherent potential to produce a given number of eggs of a certain size, to attain a required weight, to be resistant to stresses, etc Management of the flock will determine how well these genetic characters are expressed As an example, data were collected on flocks containing 300,000 meat type breeder females Average figures for some characters involved with the entire 300,000 birds are shown in Table 22 3 The figures for the best flock in the group also are given, these are much higher than those for the average of all birds But even though one flock was outstanding, there is no reason to believe that they produced according to the genetic potential, improved management might have increased their productivity However, the flock did come the closest to reaching the genetic potential Failures in the management program produced less favorable results in the other flocks

TABLE 22.3

PRODUCTION AVERAGES FOR ALL FLOCKS AND THE BEST FLOCK OF MEAT-TYPE BREEDERS

Item	Average of All Flocks (300,000 pullets)	Average of the Best Flock (5,438 pullets)
Percent pullets housed of those started	95	97
Eggs per pullet housed	156	166
Hatching eggs per pullet housed	140	156
Percent hatching eggs	91	94
Average monthly mortality (%)	1.4	0.8
Average feed/100 hens/day (males incl) (lb)	37.6	36.0
Average feed/100 hens/day (males incl) (kg)	*17.1*	*16.3*
Feed per dozen eggs (males incl) (lb)	7.5	6.7
Feed per dozen eggs (males incl) (kg)	*3.4*	*3.04*
Average percent total hatchability	86	88

Source: Arbor Acres Farm, Inc., Glastonbury, Conn.

INHERITANCE OF BODY CHARACTERS

Although many factors such as depth of body, width of body, length of keel bone, length of leg bones, etc. have a bearing on body conformation, these characters must be left to the professional geneticist in his endeavor to develop strains of birds that best meet the demands of the poultryman. However, the inheritance of body weight is a factor that is the responsibility of both the geneticist and the poultryman. This is particularly true of meat-type strains involved with the production of commercial broilers and roasters.

Body weight in broilers is closely correlated with the weight of the parents at eight weeks of age. The heritability is about 45%, and few quantitative genetic characters present a higher figure.

What 45% heritability means: Heritability is the relationship between genetic responsibility and the responsibility of the poultryman for improvements in the next generation. In this case 45% of growth is genetic, 55% is management.

Example: A flock of broiler breeder female parents has an average weight of 3.5 lb (1.59 kg) at 8 weeks of age. The geneticist wants to increase the weight of the offspring broilers, so he selects for breeding purposes only those females in the breeder parent flock that weigh 4.00 lb (1.81 kg) and breeds them when they reach maturity. Therefore, those selected are 0.5 lb (227 gm) heavier than the flock average. Broiler weight is 45% heritable. Therefore the offspring broilers from the 4-lb breeders would inherit a weight increase of 0.225 lb (102 gm) over the parent female flock (45% × 0.5 lb, or 45% × 227 gm). Assuming that no such selection was made in the male line parents, the genetic increase in broiler weight must be divided by 2, giving an increased broiler weight of 0.1125 lb (51 gm). Had the same selection pressure been made in the male line as in the female line, the increase in average broiler weight would have been 0.225 lb (102 gm).

Selection pressure: This genetic term denotes increased selection within a given flock of birds so that a smaller segment of the flock population will

be used as breeders Or, to say it another way the more birds culled from the breeding flock, the higher the selection pressure The term here is ex pressed in *percent*, denoting that percent of the flock retained for breeders The lower the percentage, the *higher* the selection pressure

Selection pressure and body weight Body weight in broilers is more closely correlated with parent body weight at 8 weeks of age than with parent body weight at sexual maturity The more pressure exerted on the parents at 8 weeks of age, the greater the improvement in the offspring broiler weights

Because commercial meat type flockowners secure parent chicks from primary breeders, these flockowners have the opportunity of exerting selection pressure at the parent level in their flocks, i e , they may use a lower percentage of the birds as breeders The higher the pressure, the more the improvement The exact relationship is shown in *Table 22 4*

TABLE 22 4

TABLE FOR CALCULATING THE EXPECTED GAIN IN POUNDS AS A RESULT OF SELECTION PRESSURE AT VARIOUS LEVELS IN THE PARENT POPULATION

Percent Selection Pressure (Retained) of Females	Percent Selection Pressure (Retained) of Males									
	100	90	80	70	60	50	40	30	20	10
	Expected Broiler Weight Gain in Pounds									
100	0 000	0 014	0 027	0 040	0 054	0 067	0 081	0 096	0 114	0 139
90	0 014	0 028	0 041	0 054	0 068	0 081	0 095	0 110	0 128	0 153
80	0 027	0 041	0 054	0 067	0 081	0 094	0 108	0 123	0 141	0 166
70	0 040	0 048	0 067	0 080	0 094	0 107	0 121	0 136	0 154	0 179
60	0 054	0 068	0 081	0 094	0 108	0 121	0 135	0 150	0 169	0 193
50	0 067	0 081	0 094	0 107	0 121	0 134	0 148	0 163	0 181	0 206
40	0 081	0 095	0 108	0 121	0 135	0 148	0 162	0 177	0 195	0 220
30	0 096	0 110	0 123	0 136	0 150	0 163	0 177	0 192	0 210	0 235
20	0 114	0 128	0 141	0 154	0 168	0 181	0 195	0 210	0 228	0 253
10	0 139	0 153	0 166	0 179	0 193	0 206	0 220	0 235	0 253	0 278

How to use Table 22 4 Select the percentage of the heaviest male birds to be kept after weighing them at eight weeks of age Find the figure at the top of the table Similarly, find the figure for the females at the left of the table Extend the male percentage column downward until it reaches the line for the female percentage The figure indicates the ex pected gain in *pounds* of broiler weight as a result of the selection at the parent level

Example Male selection retention is 60%, female retention is 80% The expected gain in weight in the broiler offspring is 0 081 lb

Note The effect of exerting pressure on one sex is exactly the same as exerting pressure on the other sex

Negative Correlation of Genetic Characters

From a genetic standpoint certain genetic quantitative characters have a positive correlation, that is, when selection is made to improve livability within the line,

egg production also increases However, many other quantitative characters have a negative correlation When selection is used to increase body weight in the next generation for instance, egg production decreases A detailed example is given in Table 22 5 When there is genetic selection pressure exerted in the parents so as to increase the broiler weight by 0 1 lb (45 4 gm) notice the effect on some other characters

TABLE 22 5

EFFECT OF GENETICALLY INCREASING THE BROILER WEIGHT BY 0 1 LB (45 4 GM)

Item	Effect
Egg production	Decreases 10 0%
Pounds of feed per dozen eggs	Increases 9%
Laying house livability	Decreases 2 3%
Hatchability	Decreases 1 2%
Chicks hatched per hen housed	Decreases 8 3%
Broiler livability	Decreases 25%

Another way of stating negative correlation If one were to weigh a group of broiler chicks, one would find that the dams of the heavier birds would produce relationships as outlined in Table 22 5 The heavier the broilers, the fewer the eggs produced by their female parents, the lower the hatchability, etc

Example If, from a given population of broilers, one were to make a segregation on the basis of 0 1 lb (45 4 gm) weight, he would find that the dams of the heaviest broilers would produce fewer eggs, as shown in Table 22 6

TABLE 22 6

RELATIONSHIP BETWEEN BROILER WEIGHT AND EGG PRODUCTION OF THE DAMS

Live Broiler Weight Lb	Kg	Eggs per Hen Housed
3 43	1 56	155
3 45	1 57	149
3 53	1 60	143
3 59	1 63	139

Body Weight Economics

The heritability percentages given in Table 22 1 show that it is relatively easy to increase the weight of a strain of chickens, but more difficult to increase the genetic potential for egg production and several other characters But when selection pressure is exerted on the line to increase weight, egg production and other factors decrease if no added pressure is placed on the line to retain the good manifestation of these characters Balanced breeding is important The geneticist must increase the weight of his line of birds no faster than he can maintain satisfactory

egg production, etc This is accomplished by placing minimum pressure on the line for body weight, while increasing the pressure for the other factors Actually, only a very small percentage of the birds will satisfy the requirements, the programs are costly Although integration has placed a greater emphasis on a balanced breeder bird—one that will grow, lay, and live well—the determining factor for a top line of meat type birds is still its ability to perform well in the broiler house

With egg type strains, the situation generally is reversed, that is, there has been emphasis for a smaller bird, one that will consume less feed but still produce the maximum number of market eggs

INHERITANCE OF EGG PRODUCTION

The inheritance of egg production presents a complicated genetic picture, for egg production is the end product of several separate genetic characters working together to cause the bird to produce a given number of eggs in a given time Of the several factors involved, the three most important are

(1) *Early sexual maturity* The younger the bird when she begins to produce eggs, the greater her egg production will be during her laying year However, this character takes on a negative value, because layers must be prevented from laying eggs at an early age, as eggs laid by young birds are smaller than those laid by older birds Feed-control and light-control programs are used to prevent early egg production Genetically, however, the gene relationship still stands

(2) *High intensity of lay* This character is manifested by the ability of the bird to lay at a rapid rate Since chickens lay their eggs in clutches—that is, they lay an egg on each of several consecutive days before they miss a day—clutch size (length) is an important genetic factor When a hen is producing at the rate of 80%, she must lay 1 egg per day 8 out of every 10 days Some birds have been known to lay eggs for 200 consecutive days before missing a day

(3) *Persistence of lay* The longer the laying cycle before the hen enters her molting period, the better egg producer she is Persistence is a definite genetic factor associated with egg production In the early days of commercial egg production, a 12 month period of production was thought to be ample, but today the requirement is for a bird that can profitably produce eggs over a 13 or 14 month period

Egg production has a low heritability percentage of 25, in other words, 75% of the egg producing ability of a hen rests with management There are so many management factors involved that it would be repetitious to mention them here Indirectly, anything that furnishes a better environment for the hen, prevents stresses and excessive mortality, and provides for her physiological well being will cause the production of more eggs

INHERITANCE OF EGG SIZE

What is ideal egg size? Modern geneticists have induced hens to lay large eggs through breed improvement But egg size is a highly variable factor, therefore, what may be ideal in one case or one segment of the laying period may not be in another

Large Egg Size May Be Important

Egg size is the result of a quantitative genetic character or characters with a high heritability. Therefore, it is relatively easy for the geneticist to increase the size of the eggs in a given strain of birds; it is less easy for the poultryman to manipulate egg size.

Regardless of whether eggs are sold by graded weight or by bulk weight, it is important to have large eggs. Extra-large eggs often command no higher price than large eggs, yet it costs more to produce them. When this is the case, strains of chickens producing excessively large eggs may have a disadvantage.

Variations in Egg Size

There are many reasons for variations in egg size. Some are the result of the natural pattern of egg production; others are the result of management; still others bear a genetic relationship.

Bird variations in egg weight: Individual birds within a given flock lay eggs of different sizes (weights). However, each bird tends to lay consecutive eggs that are similar in size to the previous egg. The only variation is when double-yolk eggs are produced by multiple ovulation. Furthermore, each bird lays eggs that are similar in shape. Although a high proportion of the hens will lay eggs that approach the average weight of all eggs laid by the flock, there will be many that produce larger or smaller eggs.

Variations in egg size throughout the laying year: When a pullet begins egg production her eggs are relatively small. Gradually egg size increases as she becomes older, until maximum size is reached near the end of her first laying cycle. If she is force molted, eggs laid during her second cycle of production will be larger than those laid during her first cycle.

Most of the first eggs laid are of relatively little value, either as commercial eggs or as hatching eggs, because of their small size. This has led poultrymen to delay the onset of egg production until later in the bird's life, when her larger egg size is commensurate with her greater age.

Changes in egg size throughout the laying year: The producer of commercial eggs is quite cognizant of the fact that egg size increases during the laying year, because he markets his eggs according to a grade weight. The greater the percentage of the heavier sizes, the greater his cash return. Egg weight grade sizes vary widely from country to country, but in the United States they are as follows:

Weight Classification	Minimum Net Weight per Dozen Eggs Ounce
Jumbo	30
Extra large	27
Large	24
Medium	21
Small	18
Peewee	15

Egg size as it affects income: Only when a premium is received for Jumbo and Extra Large eggs is there an advantage in increased egg size. However,

if eggs are to be sold on a weight basis, added size does have an economic advantage For further details regarding average egg sizes, see Chapter 23

Early egg size variation in the breeder hen From a flock standpoint, even though the first eggs laid are smaller than those laid later in the life of the hen, they are genetically similar Such small eggs should impart identical gene material to the next generation as larger eggs produced later In many instances hatcherymen use hatching eggs with a smaller minimum size at the start of production and raise the minimum requirement after about ten weeks of egg production

Chick size variation Chick size is directly related to the size of the hatching egg from which the chick is hatched Large eggs produce large chicks, small eggs produce small chicks It is also known that small chicks do better if raised separately from larger chicks This fact has caused many hatcherymen to segregate their hatching eggs into two or three weight classifications, such as large, medium, and small, prior to setting Chicks from each group are sent to individual customers, so that the chicks will be more uniform in size From a brooder house management program, this is an excellent procedure, but genetically it does have a disadvantage After the first few weeks of egg production by the breeding flock, small eggs produce small chicks, which in turn produce mature pullets that lay smaller eggs Pullets coming from large eggs would produce larger eggs

Recommendation Where there is an egg size problem in the strain of egg type birds being used, eggs should not be set according to size unless the minimum hatching weight is raised

INHERITANCE OF EGG QUALITY

Egg quality includes a study of the quality of the eggshell and the quality of the interior contents Although not as important in meat-type strains as in commercial egg producing strains, egg quality has a greater value today than it did several years ago

Eggshell Quality

One measure of eggshell quality is its thickness The thicker the shell the more resistant it is to breakage Eggshell thickness is a quantitative genetic factor with relatively low heritability The thickness of the shell may be altered by various factors of management temperature, stress disease, feed, and others

Some shell abnormalities are inherited Chalky shells, ridges, etc , may be the result of gene variations Other abnormalities are often due to imperfections in the area of the oviduct where the shell is deposited

Interior Egg Quality

Albumen quality has a heritability of about 25% Therefore, inferior quality is more often the result of improper flock management than of the manifestation of genetic action

Blood spots have a very low heritability However, they have become associated with some breeds of chickens Eggs from those breeds laying brown-shelled eggs have a higher incidence of blood spots than eggs with white shells

Interior egg quality may be improved within a strain of chickens, and commercial poultrymen are ever on the lookout for those strains that produce good eggs

However, albumen quality deteriorates the longer a bird is in egg production, the warmer the weather, and during the occurrence of certain diseases. The incidence of blood spots is also highly variable in different strains.

FEATHER SEXING

Slow feathering in the young chicken is due to a *qualitative sex linked, dominant* gene "K". Its allele, rapid feathering, is the response of the recessive gene, "k". Although the predominant feature of the recessive gene is to cause the feathers to grow more rapidly during the first six to eight weeks of the chick's life, the difference between slow and fast feathering is obvious at the time the chick is hatched, but only in the relationship of the length of the primary wing feathers to the length of the primary wing coverts, which are small downy feathers covering the base of the primary feather shafts. A description of the fast feathering and slow-feathering wing in the day old chick is as follows:

Slow feathering (K). At hatching time all the primary feathers are short, but the coverts extend only one half to three-fourths the length of the primaries. *The coverts are always shorter than the primaries.*

Rapid feathering (k). When the chicks hatch, the primary feathers are longer than in the case of chicks with slow feathering. *The coverts are always as long as or longer than the primaries.*

Examining Day-old Chicks for Feathering

From the top, and under a good light, examine the feathers on the primary web of the outspread wing. Note that the coverts emerge from well up on the surface of the wing, and the primaries arise from the lower edge. The *relative length* of the primaries and coverts is more important than the overall length of the feathers, since overall length depends on the length of time that the chicks have been out of the shell.

Day-old Feather Sexing

Slow feathering and rapid-feathering genes may be used in a breeding program, to make it possible to determine the sex of day-old chicks by feather sexing, the term applied to this type of inheritance.

How to make the cross. When a rapid feathering male, *kk*, is mated to slow-feathering females, *K-*, sex-linked inheritance is involved, and the speed of feathering reverses itself in the chicks of the next generation. Thus, the offspring chicks from such a mating would show males that are slow-feathering, *Kk*, and females that are rapid feathering, *k*. See Chapter 21.

Important. The *reciprocal* of this cross will not provide sex linkage and feather sexing possibilities in the offspring chicks. *Remember* that the male parent must be homozygous for recessive rapid feathering, *kk*.

Special lines involved. To make it possible to sex segregate day-old chicks, it is necessary that special parent lines of birds be developed. The male line must be homozygous for rapid feathering, the female line must be hemizygous (pure) for slow feathering.

SOCIAL ORDER IN CHICKENS

Although genetic makeup has a great influence on the behavior of chickens, the social order within a pen or flock of sexually mature birds takes on unusual sig

nificance in a study of bird behavior This characteristic is sometimes known as the *peck order*

Within a group of birds, either male or female, there are certain birds that seem to dominate others of the same sex In fact, the domination extends to the point where one male dominates all other males and ranks as number one in the social order Then there is the next male in line He is number two, and dominates all males but number one, etc , until finally there is the male at the bottom of the order, he is dominated by all other males in the pen Similar relationships are established by the females within the group In most instances the domination is evidenced by pecking and fighting

The *peck order* gives rise to a broader classification of the birds *aggressive* and *timid*, although there is no clear-cut distinction But the division does have a bearing on many management factors The aggressive birds continually get more feed and water than the timid ones Thus, relatively speaking, the larger birds get too large, and the timid birds remain small

Timid Hens Are Afraid

In many laying houses the peck order is of such magnitude that the timid pullets are forced off the floor and onto slats, perches, or equipment Many times they cannot get to feed and water, or will not go to the feeders or waterers because of fear of being "pecked" by the more aggressive individuals The only management salvation is to give special care to the timid individuals by providing feed and water at a location they most often frequent

When feed restriction is practiced, there is always the chance that the timid birds will not remain at the feeders long enough to consume an adequate amount of feed Timid males often cause a reduction in average flock fertility They frequent areas away from the hens to keep away from the aggressive males, thus the number of matings by these timid males is materially reduced

Social Order Groups Within a Pen

It has been shown that when the number of birds within a given pen is large, males and females do not have the memory to identify all the other birds in the pen, and it becomes difficult to set up a social order for the entire pen In these cases there are suborders within the pen The size of these groups is dependent on the ability of the males and females to identify a certain number of birds with respect to their social order One hundred females is certainly the maximum

Space area is also involved in these suborders Most people feel that the maximum is between 200 and 300 sq ft (18 5-29 sq m) of floor space Birds usually do not go outside their suborder space area unless frightened or disturbed They are very hesitant to go to another location to get feed or water because they will be chased back to their own territory This fact makes it necessary, for the best management practice, that feeders, waterers, and nests be distributed over the various areas of large pens

Equipment Recommendation

On the basis of the above information the recommendation is made that equipment be placed within the pen or house so that no bird will have to go more than 10 feet (3 m) to get to feed, water, or a nest

Production Standards

Every line of chickens has a bred-in potential for each genetic *quantitative* character For instance, genes that affect egg production are present When management is correct, there will be full expression of these genes But management is not always good enough to get the full gene potential, there will be all sorts of variation in the number of eggs a bird will produce All the geneticist can do is make a statement that under good management, his line of birds will produce a calculated number of eggs Those poultrymen who get more eggs from their birds than the calculated number will have done a fine job, those who get fewer will have done a poor job These calculated figures may be termed "standards " They are not averages of what the birds will accomplish under field conditions, but should be somewhat higher Neither are they goals that can be attained only on rare occasions

Importance of Standards

Most commercial poultrymen have the problem of not being able to determine whether their birds are doing well or poorly The underlying cause of this difficulty is that there are day to-day changes in the expression of most quantitative characters in the chicken Birds get larger, egg production first increases and then decreases during the laying year, egg size generally increases the longer a bird lays, hatchability varies, etc Standards set forth certain figures that indicate optimum behavior for many of these characters If the standards are given on a weekly basis, they offer a means for the flockowner to compare the weekly productivity of this flock with figures that are standard for the particular line of birds involved He then knows whether the flock is producing at standard, below standard or above standard, he knows whether he is doing a good or a poor job of management

What Standards are Important

Standards necessary as an aid to better management may be segregated according to the age and type of birds

(1) *Growing birds*
- body weight,
- livability

(2) *Commercial egg producing birds*
- percent hen-day egg production,
- cumulative total egg production, hen housed basis,
- body weight,
- egg size,
- livability

(3) *Breeding birds*
- percent hen-day egg production,
- cumulative total egg production, hen housed basis,
- percent hatching eggs, hen-day basis,
- cumulative hatching eggs produced per hen housed,
- percent total hatchability,
- body weight,
- livability

Figures Are a Guide Only

These standard figures follow They can be offered only as a guide, as each strain of chickens differs in its inherited ability to produce at a given rate However, the figures in the tables are quite representative of averages of all lines For the poultryman who wishes data for the particular strain of birds he is using, the primary breeder should be contacted

STANDARDS FOR GROWTH

Growth standards are highly variable, depending on the strain and type of birds, sex, feeding and management programs, and environmental conditions The relationship between feeding and growth is shown in Chapter 34, where several sets of growth standards are given for various lines of chickens

STANDARDS FOR COMMERCIAL EGG PRODUCING BIRDS

The standards presented in this section take into consideration egg production as a derivative of hen housed and hen-day egg production, plus some other measurements A careful study of these figures and their correlation one with another will give the commercial poultry producer a better insight as to the interrelationship between the figures

Production Standards for Commercial Layers

Tables 23 1 and 23 2 give the production standards for Leghorns and medium size (laying brown shelled eggs) layers respectively The standards show the following

Item	Table 23 1 Leghorns	Table 23 2 Medium size
Eggs produced, 52 weeks, hen-day	240	233
% production at peak, hen-day	92	88
Average % hen-day production	71	69
Average % hen housed production*	66	64

*Note Mortality is based on an average of 1 25% per month

How to Use the Standards

Because the standards are indicative of what a good strain of birds should do under good management practices, they offer a means of comparing the egg production of an actual flock of birds with the standard figures If actual egg production is below the standards, there is a problem, when the actual figures are at or above the standards management is fulfilling its requirements As the egg production standards are given on a weekly basis, the comparison may be made at any time during the production cycle

Hen-day and Hen housed Egg Production

Common to the industry are two methods of measuring daily or weekly egg production Each has its fallacies as an index, but each is a good rule of thumb

Hen day egg production This is a measure of the egg productivity of the live hens on any given day

TABLE 23.1

PRODUCTION STANDARDS FOR EGG-TYPE COMMERCIAL LEGHORNS

Week of Egg *Production*	% Hen-day Egg *Production*	% Hen-housed Egg *Production*	Cumulative Egg Production per *Hen Housed*
1	5	5	0.3
2	18	16	1.5
3	34	32	4
4	54	50	7
5	71	68	12
6	89	83	18
7	92	90	24
8	91	89	30
9	90	88	36
10	89	87	42
11	88	86	48
12	88	85	54
13	87	84	60
14	86	83	66
15	85	83	72
16	85	82	78
17	84	81	83
18	83	80	89
19	82	79	94
20	82	78	100
21	81	77	105
22	80	76	111
23	79	75	116
24	78	74	121
25	78	73	126
26	77	72	131
27	76	71	136
28	75	70	141
29	75	70	146
30	74	69	151
31	73	68	155
32	72	67	160
33	72	66	165
34	71	65	169
35	70	64	174
36	69	63	178
37	69	62	183
38	68	61	187
39	67	60	191
40	66	59	195
41	66	59	199
42	65	58	203
43	64	57	207
44	63	56	211
45	63	55	215
46	62	54	219
47	61	53	223
48	60	52	226
49	60	51	230
50	59	50	233
51	58	49	237
52	57	48	240

TABLE 23 2

PRODUCTION STANDARDS FOR MEDIUM SIZE COMMERCIAL LAYERS*

Week of Egg Production	% Hen-day Egg Production	% Hen housed Egg Production	Cumulative Egg Production per Hen Housed
1	5	5	0 4
2	17	17	1 5
3	31	30	4
4	48	47	7
5	65	63	11
6	82	80	17
7	88	86	23
8	87	85	29
9	86	85	35
10	86	84	41
11	85	83	47
12	85	82	52
13	84	81	58
14	83	80	64
15	82	79	69
16	82	78	75
17	81	78	80
18	80	77	85
19	79	76	91
20	79	75	96
21	78	74	101
22	78	73	106
23	77	73	111
24	76	72	116
25	76	71	121
26	75	70	126
27	74	69	131
28	73	68	136
29	73	68	141
30	72	67	145
31	71	66	150
32	71	65	154
33	70	64	159
34	69	63	163
35	69	62	168
36	68	61	172
37	67	60	176
38	66	60	180
39	66	59	184
40	65	58	188
41	64	57	192
42	64	56	196
43	63	55	200
44	62	55	204
45	62	54	208
46	61	53	212
47	60	52	215
48	60	51	219
49	59	50	222
50	58	49	226
51	58	49	229
52	57	48	233

*Producing brown-shelled eggs.

Example: There are 1,000 hens alive on a certain day and they produce 750 eggs that day. Their *hen-day egg production* is 75%.

Formula: $\dfrac{\text{Number eggs produced}}{\text{Number live hens}} \times 100 = \%\text{ hen-day production}$

Hen-housed egg production: This is a measure of the egg productivity in relation to the number of hens (housed) at the beginning of the laying period.

Example: 1,200 hens were "housed" at the beginning of the laying "year." Today they laid 750 eggs. Their *hen-housed egg production* is 62.5%.

Formula: $\dfrac{\text{Number eggs produced}}{\text{Number hens housed}} \times 100 = \%\text{ hen-housed production}$

Difficulties with Hen-day and Hen-housed Interpretations

Although *hen-day egg production* is an excellent indicator of how well the live birds are laying, it does not consider egg size or egg quality. Since these factors determine egg income, hen-day egg production is often misleading from a profit standpoint. Neither does the index account for mortality. Theoretically, one could lose all but 4 from a flock of 1,200 hens housed, and if he got 3 eggs on 1 day the hen-day production would be 75%. However, it is the best production index available to the industry. Almost everyone uses it.

The other index, *hen-housed production*, is not reliable either, as it includes both egg production and cumulative flock mortality. Therefore, there are many combinations of egg production and death loss that could give an identical hen-housed production figure. But from a cost-of-egg-production standpoint, this percentage is good because it includes both production and mortality. It tells what the flock has done and is doing. However, as in the case of hen-day production, there is no indication of egg size and egg quality.

Period of Laying Year and Egg Size by Percentages

The first eggs laid during the production period are smaller than those laid later, egg size gradually increasing as the pullet continues to lay. Since eggs are marketed by weight classifications, the producer is extremely interested in standards for the percentage of eggs that fall into each size as the bird continues production. These can be found in Table 23.3, by four-week periods for Leghorns as a guide only. Each strain of birds will vary; and many management, nutritional, and environmental factors will affect the percentages. The table exemplifies a strain of birds whose average egg weight throughout the first laying cycle is 25.4 oz to the dozen (60.0 gm each). This egg weight is about average; it is neither large nor small. Strains of birds laying larger eggs would produce different percentages of the grade sizes listed, as would those laying smaller eggs.

Period of Lay and Number of Eggs Produced by Sizes

In Table 23.3, the percentages of eggs laid in each weight classification are given. Table 23.4 shows the standard figures as a guide to determine the actual number of eggs that would be produced. The standards involve birds that have a capacity to produce 240 eggs in 52 weeks of lay with an average egg weight of 25.4 oz per dozen (60.0 gm each). The percent Large-and-over eggs is 76.4, which is about average for all strains of Leghorns, although some are known to produce larger eggs than this; but there are many that produce smaller eggs.

TABLE 23 3

STANDARD RELATIONSHIP BETWEEN WEEK OF EGG PRODUCTION AND EGG SIZE BY PERCENT
(Commercial Leghorns)

Weeks of Egg Production by 4 Wk Periods	Size of Eggs: Peewee, Small Under 21 Oz* Under 49 6 Gm**	Medium 21-23 9 Oz 49 6-56 6 Gm	Large 24-26 9 Oz 56 7-63 7 Gm	Ex Large, Jumbo 27 Oz and Over 63 8 Gm and Over
	Percent of Total Eggs Produced			
1-4	60	30	10	0
5-8	13	56	29	2
9-12	5	46	44	5
13-16	2	34	56	8
17-20	1	23	63	13
21-24	0	15	67	18
25-28	0	11	66	23
29-32	0	7	64	29
33-36	0	5	63	33
37-40	0	3	59	38
41-44	0	2	57	41
45-48	0	1	55	44
49-52	0	0	52	48

* Per dozen.
** Each
Weighted average egg weight, 25 4 oz/doz (60 0 gm/ea)

TABLE 23 4

STANDARD RELATIONSHIP BETWEEN WEEK OF EGG PRODUCTION AND EGG SIZE BY NUMBERS
(Commercial Leghorns)

Weeks of Egg Production by 4 Wk Periods	Size of Eggs: Peewee, Small Under 21 Oz* Under 49 6 Gm**	Medium 21-23 9 Oz 49 6-56 6 Gm	Large 24-26 9 Oz 56 7-63 7 Gm	Ex Large, Jumbo 27 Oz and Over 63 8 Gm and Over	Total
	Number of Eggs Produced per Hen Housed				
1-4	4 2	2 1	0 7	0	7
5-8	3 0	12 9	6 6	0 5	23
9-12	1 2	11 0	10 6	1 2	24
13-16	0 5	8 2	13 4	1 9	24
17-20	0 2	5 0	13 9	2 9	22
21-24	0	3 1	14 1	3 8	21
25-28	0	2 2	13 2	4 6	20
29-32	0	1 3	12 2	5 5	19
33-36	0	0 9	11 2	5 9	18
37-40	0	0 5	10 0	6 5	17
41-44	0	0 3	9 1	6 6	16
45-48	0	0 1	8 3	6 6	15
49-52	0	0	7 3	6 7	14
Total	9 1	47 6	130 6	52 7	240

* Per dozen.
** Each
Weighted average egg weight, 25 4 oz/doz (60 0 gm/ea)
Percent Large and over 76 4

TABLE 23.5

PRODUCTION STANDARDS FOR EGG-TYPE BREEDER LEGHORN HENS

Week of Egg Production	% Hen-day Egg Production	Cumulative Hen-housed Egg Production	% Hatching Eggs (Hen-day)	Cumulative Hatching Eggs per Hen Housed	% Total Hatchability
1	5	0.4	—	—	—
2	16	1.5	—	—	—
3	34	4	—	—	—
4	54	7	54	2	75
5	72	12	60	5	80
6	85	18	65	9	83
7	88	24	70	13	86
8	87	30	74	18	88
9	87	36	78	22	89
10	86	42	81	27	90
11	85	48	84	32	90
12	84	53	86	36	90
13	84	59	69	40	90
14	83	64	71	44	90
15	82	70	72	48	90
16	81	75	74	52	90
17	81	81	75	56	89
18	80	86	77	60	89
19	79	91	78	64	88
20	78	96	79	68	88
21	78	101	81	72	88
22	77	106	82	76	87
23	76	111	83	81	87
24	76	116	84	85	86
25	75	121	85	89	86
26	74	126	86	93	86
27	73	131	87	97	85
28	73	135	88	101	85
29	72	140	89	105	84
30	71	145	89	110	84
31	70	149	90	114	83
32	70	153	91	118	83
33	69	158	91	122	82
34	68	162	92	126	82
35	67	166	92	129	81
36	67	171	93	133	81
37	66	175	93	137	80
38	65	179	94	141	80
39	65	183	94	145	79
40	64	187	95	148	79
41	63	191	95	152	78
42	62	194	95	156	78
43	61	198	96	159	77
44	61	202	96	163	76
45	60	205	96	166	76
46	59	209	96	170	75
47	59	212	97	173	75
48	58	216	97	176	74
49	57	219	97	179	74
50	57	222	97	183	73
51	56	225	98	186	72
52	55	228	98	189	72

TABLE 23 6

PRODUCTION STANDARDS FOR MEDIUM SIZE BREEDER HENS

Week of Egg Production	% Hen day Egg Production	Cumulative Hen Housed Egg Production	% Hatching Eggs (Hen day)	Cumulative Hatching Eggs per Hen Housed	% Total Hatchability
1	5	0 4	—	—	—
2	15	1 4	—	—	—
3	29	3	—	—	—
4	45	6	20	0 6	71
5	62	11	40	2 3	74
6	78	16	56	5	78
7	84	22	68	9	80
8	83	27	77	13	82
9	82	33	83	18	84
10	82	39	87	23	85
11	81	44	89	28	85
12	80	49	91	33	86
13	79	55	92	38	86
14	78	60	93	43	86
15	78	65	94	48	86
16	77	70	95	53	86
17	76	76	95	58	86
18	76	81	96	63	86
19	75	86	96	67	86
20	74	91	96	72	85
21	73	95	96	77	85
22	73	100	96	81	85
23	72	105	96	86	85
24	71	110	95	90	84
25	70	114	95	95	84
26	70	119	95	99	84
27	69	123	95	103	84
28	68	128	95	108	83
29	67	132	95	112	83
30	67	136	95	116	83
31	66	141	94	120	82
32	65	145	94	124	82
33	64	149	94	128	82
34	64	153	94	132	81
35	63	157	94	135	81
36	62	161	94	139	80
37	61	165	93	143	80
38	60	169	93	146	80
39	60	172	93	150	79
40	59	176	93	153	79
41	58	180	93	156	79
42	58	183	93	160	78
43	57	187	92	163	78
44	56	190	92	166	78
45	55	194	92	169	77
46	55	197	92	172	77
47	54	200	91	175	76
48	53	203	91	178	76
49	52	207	91	181	75
50	52	210	91	184	75
51	51	213	90	186	74
52	50	216	90	189	74

Egg size variations: One factor of great importance in the determination of egg size is the temperature of the air surrounding the birds. High temperatures decrease egg size, and if the hot season comes at the end of the egg production period, egg weight (size) will suffer. This distorts the percentages of eggs in each grade during this period. The standards shown in Table 23.4 make no compensation for such changes, as evidenced by the

TABLE 23.7

PRODUCTION STANDARDS FOR MEAT-TYPE BREEDER HENS

Week of Egg Production	% Hen-day Egg Production	Cumulative Hen-housed Egg Production	% Hatching Eggs (Hen-day)	Cumulative Hatching Eggs per Hen Housed	% Total Hatchability
1	5	0.4	—	—	—
2	18	1.6	—	—	—
3	44	5	20	0.6	70
4	68	10	50	3	75
5	82	15	66	7	80
6	81	21	77	11	84
7	80	26	83	16	87
8	79	32	87	20	88
9	77	37	91	25	89
10	76	42	93	30	90
11	75	47	94	35	90
12	74	52	95	40	90
13	72	57	95	44	90
14	71	62	96	49	89
15	70	67	96	53	89
16	69	71	96	58	89
17	67	76	97	62	89
18	66	80	96	67	88
19	65	85	96	71	88
20	64	89	96	75	88
21	63	93	96	79	87
22	62	97	96	83	87
23	61	101	96	87	87
24	60	105	95	90	86
25	58	109	95	94	86
26	57	113	95	97	85
27	56	116	95	101	85
28	55	120	95	104	84
29	54	123	95	107	84
30	52	126	95	110	83
31	51	130	94	114	83
32	50	133	94	116	82
33	49	136	94	119	82
34	47	139	94	122	81
35	46	141	94	125	81
36	45	144	94	127	80
37	44	147	93	130	80
38	43	149	93	132	79
39	41	152	93	134	79
40	40	154	93	137	78
41	39	156	93	139	77

fact that the percentage of the larger egg sizes increases until the end of the laying year

STANDARDS FOR BREEDING BIRDS

Production standards for breeders have been segregated according to

(1) egg type Leghorn breeder hens,
(2) medium size breeder hens (producing brown-shelled eggs),
(3) meat type breeder hens

Not only are figures given for hen-day and hen housed egg production, but there are standards for percent hatching eggs, cumulative hatching eggs, and percent total hatchability As with other standards, these figures are for good flocks given good care It must be kept in mind, however, that egg production is generally lower with breeder lines than with commercial egg producing lines Meat type breeders produce fewer eggs over a shorter period of egg production than egg type breeders

Certain figures for each of the 3 groups cannot be shown in the 3 tables They are as follows

	Table 23 5 Leghorns	Table 23 6 Medium-size	Table 23 7 Meat type
Total hen-day egg production (52 wk)	253	233	
Total hen-day egg production (41 wk)			166
Total hen housed egg production (52 wk)	228	216	
Total hen housed egg production (41 wk)			156
Percent production at peak (hen-day)	88	84	82
Hatching eggs per hen housed (52 wk)	189	189	
Hatching eggs per hen housed (41 wk)			139

Record Management

Flock production records are a necessary part of good flock management. Some records, such as those of mortality, egg production, and feed consumption, must be kept on a daily basis; others can be kept on a less frequent basis. In most cases, daily records should be summarized at the end of each week and placed in a permanent file. Certain calculations are necessary at this time too. The amount of feed required to produce a dozen eggs, feed consumption per 100 females, hatching eggs per hen housed, and others fall in this category.

Weekly summary records may be divided according to the following groups:

(1) growing records;
(2) laying records;
(3) hatchability records.

SUMMARY RECORDS

Growing Summary

This is a record of flock behavior from one day of age to sexual maturity. An example is given in Fig. 24.1. In this form certain standards have been inserted at weekly intervals. This makes it possible for the poultryman to make regular comparisons between the actual and the standard. There is no need to refer to separate tables.

There are columns for number of birds alive, depletion (mortality), culling, cumulative depletion, feed consumption, and body weight.

Flock Production Summary

Similar to the Growing Summary is a Flock Production Summary. An illustration is given in Fig. 24.2 for a flock of egg-type Leghorn breeder females. By deleting the columns having to do with production of hatching eggs and substituting data for the production of commercial eggs, the sheet can be used for commercial layers. Items included in Fig. 24.2 are number of birds, flock depletion, total egg production, percent hen-day egg production, hatching egg production, feed consumption, and body weight. Notice how certain standards of production are inserted to make it possible to compare actual weekly figures with standard figures. The example is used to record the flock data for 26 weeks; a second sheet is used for the remaining 26 weeks of the year.

Two special computations are needed each week:

(1) average feed consumed per 100 females per day for the week (males included);
(2) feed per dozen eggs to date (males included).

These two calculations serve as excellent guidelines for the amount of feed being consumed. Most feed recommendations are given according to (1) above, thus exemplifying the importance of the calculation.

ARBOR ACRE

Use Separate Sheet for Each Line and Sex

FLOCK GROWI

No Shipped ________ No Dead on Arr

No Started (Incl extras) ________ Date St

Breed or Line ________ Sex ________ Source ________

No Housed at 5% Production ________ % H

Flock No ________ House No ________ Pen No ________

Date Housed ________ Laying House N

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
		PRIOR TO FIRST SELECTION				FIRST SELECTION		AFTER FIRST S	
						Removed			
Date End of Week	Age in Wks	Number Birds End of Week	Number Depleted During Week	% Depletion This Wk	Cum % Depletion	Number	% of Started	Number Birds End of Week	No Depleted During Week
	1			%	%				
	2			%	%				
	3			%	%				
	4			%	%				
	5			%	%				
	6			%	%				
	7			%	%				
	8			%	%		%		
	9			%	%		%		
	10			%	%		%		
	11			%	%		%		
	12			%	%		%		
	13			%	%		%		
	14			%	%		%		
	15								
	16								
	17								
	18								
	19								
	20								
	21								
	22								
	23								
	24								
	25								
	26								
	27								
	28								
	29								
							Cumulative Summary		

Explanations This sheet to be used until week of 5% production on H D basis

Cols 5 6 — % of those started (including extras)

Col 7 — Selection pressure removal should be completed during 8th week

Col 8 — % removed of those *started at time of First* Selection - Program calls for 8th week

Col 11 — The number of birds remaining after the First Selection is the basis for determining % depletion thereafter

Col 12 — This column is to include the last figure in Column 6 plus the % weekly depletion in Col 11.

Cols 13, 16, 17 Insert either "pounds" or " Kgs "

Complete at end Growing Period"

(1) Total feed consumed by males of mating ________

(2) Total feed consumed this sheet (Col 14) ________

Total feed consumed males and females

(3) (Add Lines 1 and 2) ________

Tot feed consumed per female at 5% prod *(Males incl)*

(4) (Divide Line 3 by no females at 5% prod.) ________

FIG. 24 1 FLOCK

S FARM, INC

NG SUMMARY

Branch ____________________

ival ____________

arted ____________

loused ____________ %

) ____________

LINE: WR, 50, 60, AA50, AA60

SEX: FEMALE

FLOCK PRODUCTION
GROWING SUMMARY
INT'L # 2037
Rev May, 1969

(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
ELECTION		FEED CONSUMED IN LBS /KGS				BODY WEIGHT				
% Depletion This Week	Cum % Depletion	This Week	Cumulative To Date	Ave /100 Females/Day for Week (Males Incl)		Actual	Standard			
							Pounds		Kgs	
				Actual	Estimated		Min	Max	Min	Max
							2 36	2 48	1 07	1 13
%	%						2 54	2 67	1 15	1 21
%	%						2 72	2 86	1 23	1 30
%	%						2 90	3 05	1 32	1 38
%	%						3 07	3 22	1 39	1 46
%	%						3 25	3 41	1 47	1 55
%	%						3 43	3 60	1 56	1 63
%	%						3 60	3 78	1 63	1 72
%	%						3 78	3 97	1 72	1 80
%	%						3 96	4 16	1 80	1 89
%	%						4 13	4 34	1 87	1 97
%	%						4 31	4 53	1 96	2 06
%	%						4 49	4 72	2 04	2 14
%	%						4 66	4 89	2 11	2 22
%	%						4 84	5 08	2 20	2 30
%	%						5 02	5 27	2 28	2 39
%	%						5 19	5 45	2 35	2 47
%	%						5 37	5 64	2 44	2 56
%	%						5 52	5 80	2 50	2 63
%	%						5 65	5 93	2 5[illegible]	2 69
%	%						5 76	6 05	2 61	2 74
%	%						5 [illegible]	[illegible] 15	2 [illegible]	2 79
%	%						5 94	[illegible] 24	2 69	2 83
	%									

GROWING SUMMARY

Page 1

ARBOR ACRES
FLOCK PRODUCT

Flock No ________ House No ________ Pen No ________ No Housed ________ Males ________

Standard Hatching Egg Min 22 Ozs/dz 52.0 Gms/each

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
		NO. BIRDS END WK		FLOCK DEPLETION				TOTAL EGG PRODUCTION			% H-D PROD	
				Female		Male						
Date End of Week	Wks in Prod	Female	Male	% Wk	% Cum	% Wk	% Cum	No Eggs For Week	Cum Eggs to Date	Cum Eggs H H to Date	This Week	Standard
	1											5
	2											18
	3											44
	4											68
	5											82
	6											81
	7											80
	8											79
	9											77
	10											76
	11											75
	12											74
	13											72
	14											71
	15											70
	16											69
	17											67
	18											66
	19											65
	20											64
	21											63
	22											62
	23											61
	24											60
	25											58
	26											57

FIG 24-2 FLOCK

FARM, INC.

ION SUMMARY **MATING: VT-M x AA50, AA60-F**

FLOCK PRODUCTION
PROD SUMMARY
INT'L. # 2054
Rev. May, 1969

__Females Date Chicks Started ________________ Branch______________

Your Hatching Egg Min __________ Ozs / dz _______ Gms./each Age 5% Prod __________ Wks

(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
HATCHING EGG PRODUCTION							FEED CONSUMPTION IN LBS./KGS					
% Hatching Eggs		Hatching Eggs Produced			Cum Hatching Eggs/H H		This Week	Cumulative Feed	Av./100 Fem /Day for Wk (Males Inc)		Feed per Doz Eggs to Date (Incl Male)	Female Body Wt
		For Week		Cumulative Total								
Act	Std	Total	Cases		Act	Std			Actual	Est		
	–					–						
	–					–						
	20					6						
	50					3 0						
	66					7						
	77					11						
	83					16						
	87					20						
	91					25						
	93					30						
	94					35						
	95					40						
	95					44						
	96					49						
	96					53						
	96					58						
	97					62						
	96					67						
	96					71						
	96					75						
	96					79						
	96					83						
	96					87						
	95					90						
	95					94						
	95					97						

PRODUCTION SUMMARY

Hatchability Summary

A weekly summary of hatchability is a necessary part of flock records An example of such a form is shown in Fig 24 3, to be used for meat type breeder females Included in the data are number of hatching eggs set, total chicks hatched, percent total hatch, percent grade outs, percent salable chicks, and number of salable chicks Weekly standard figures for percent total hatch are included in order to make a direct comparison with the actual

How to record the weekly data Weekly hatchability data should be inserted on the form according to the week the eggs were laid rather than the week the chicks were hatched This gives a more direct correlation between hatchability and egg production

Total hatch and salable hatch Total hatch refers to the number of chicks "scooped" from the trays prior to any grading Salable hatch includes only those chicks that are invoiced Thus, the total hatch, minus the culls and extra chicks, equals the salable hatch Both figures have been included on the form, because neither one alone is adequate for a complete analysis of the hatchability records

SUMMARY GRAPHS

As the weekly data are inserted on the various Summary Records, visual analysis of production results become more difficult There are too many figures on too many forms But the Summary Record form is important, for it is the sheet on which the figures are kept

To get a better picture of flock behavior, the figures on the Summary Record should be transferred to a graph Furthermore, the graph should show the standards for the factors measured Variations in actual production from the standards will be quickly evident Examples of such graphs are shown in the following figures

Flock Growing Graph

Figure 24 4 is to be used to plot the weekly growing flock data for body weight and feed consumption of a meat type female line Notice how the standard figures for these two factors are inserted on the graphs with a shaded area depicting the confines of body weight There is no set standard for cumulative flock depletion, but such figures could be inserted on the graph, a scale is provided

Flock Production Graph

Figures from the Flock Growing Record should be plotted on the Flock Production Graph, Fig 24 5 This particular graph is for a meat type line of birds and better shows the many "standard" curves relating to breeders Graphs for commercial egg line females would not include any curves for factors such as hatching eggs and hatchability The standard curves on Fig 24 5 include percent total hatch, cumulative hatching eggs, female body weight, percent hen day egg production, feed per 100 females per day (males included), and percent cumulative depletion on a hen housed basis

HOUSE RECORD RECAP

An analysis of actual flock production should be made at the end of the laying period Certain calculations are necessary in such a *House Record Recap*, they

Use Separate Sheet For
Each Female Flock or House

ARBOR ACRES FARM, INC.
HATCHABILITY SUMMARY

FLOCK PRODUCTION
HATCHABILITY
INT'L # 2073
Rev. May, 1969

Flock No.________ House No.________ Pen No.________

No. Females at 5% Production ________________

Date at 5% Production ________________

Date 1st Hatching Egg Prod. __________ Age ________

MATING: 50, 60-M x WR-F

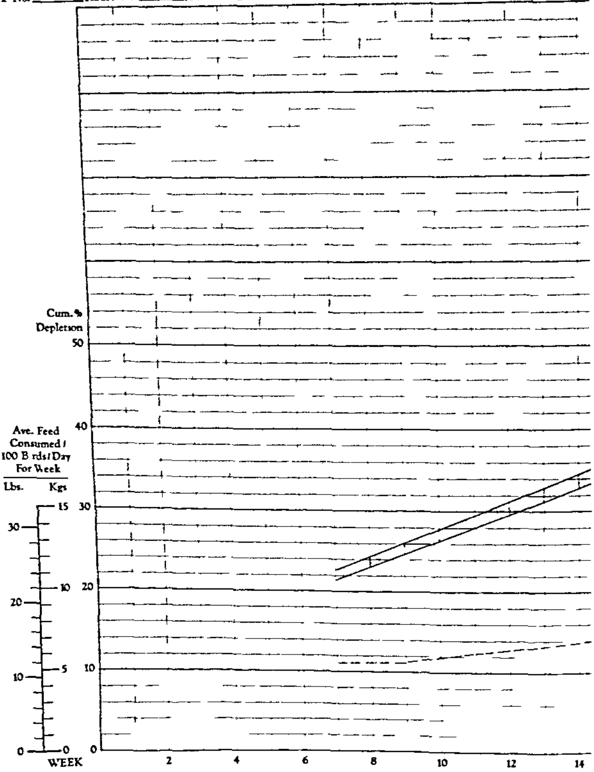
Branch ________________

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				CHICKS HATCHED FROM EGGS SET THIS WEEK					
								Salable	
Week of Egg Production	Date, End of Week of Production	Date, End of Week of Hatching	Number of Eggs Set This Week	Total	% Total Hatch	Standard % Total Hatch	% Grade-Out	%	Number
1						–			
2						–			
3						–			
4						74			
5						77			
6						79			
7						81			
8						83			
9						84			
TOTAL									

FIG. 24-3. HATCHABILITY SUMMARY

ARBOR ACR
FLOCK GROW

Flock No. ________ House No. ________ Pen No. ________ Affiliate ________



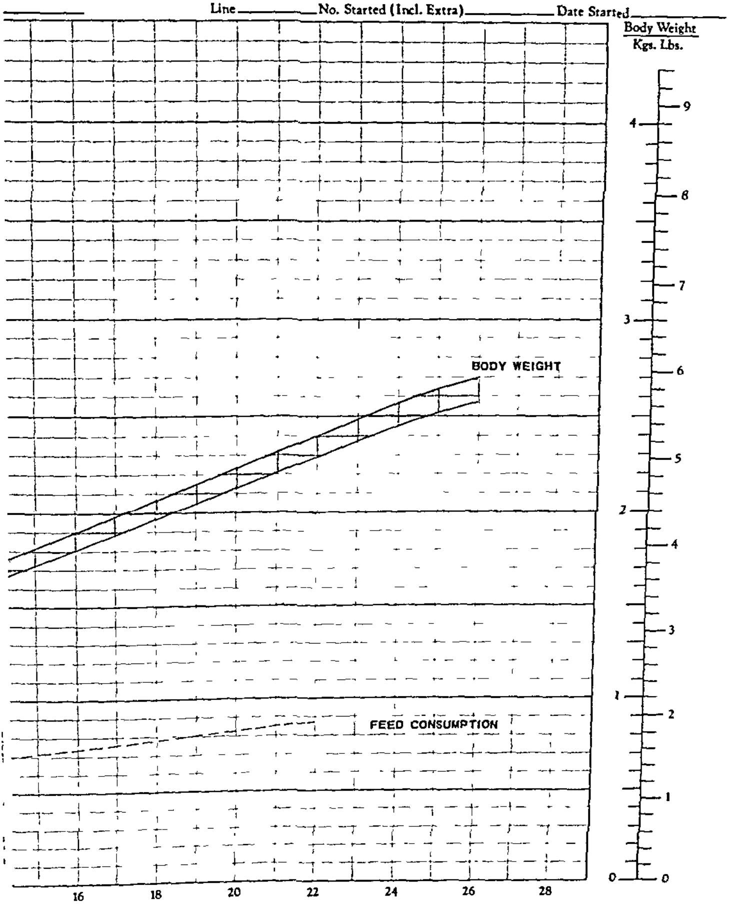
MONTH AND DAY

FIG 24-4 FLOCK

:ES FARM

ING RECORD

LINE: 50, 60, WR, AA50, AA60
SEX: FEMALE

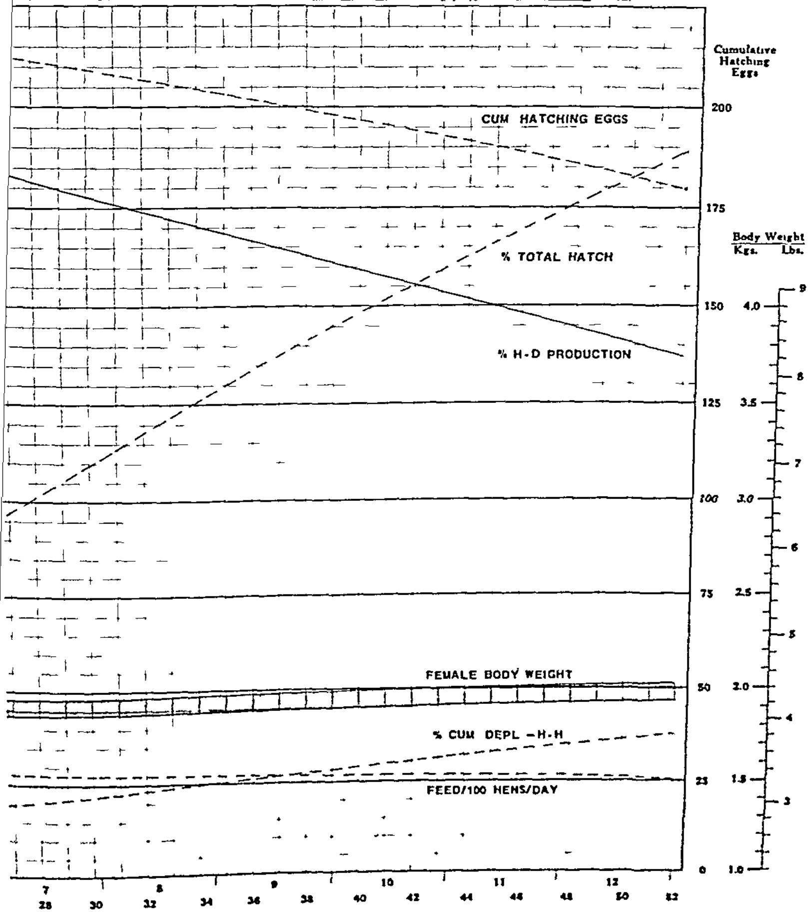


GROWING GRAPH

ES FARM
TION RECORD

22 x 66 (LEGHORN) #2119

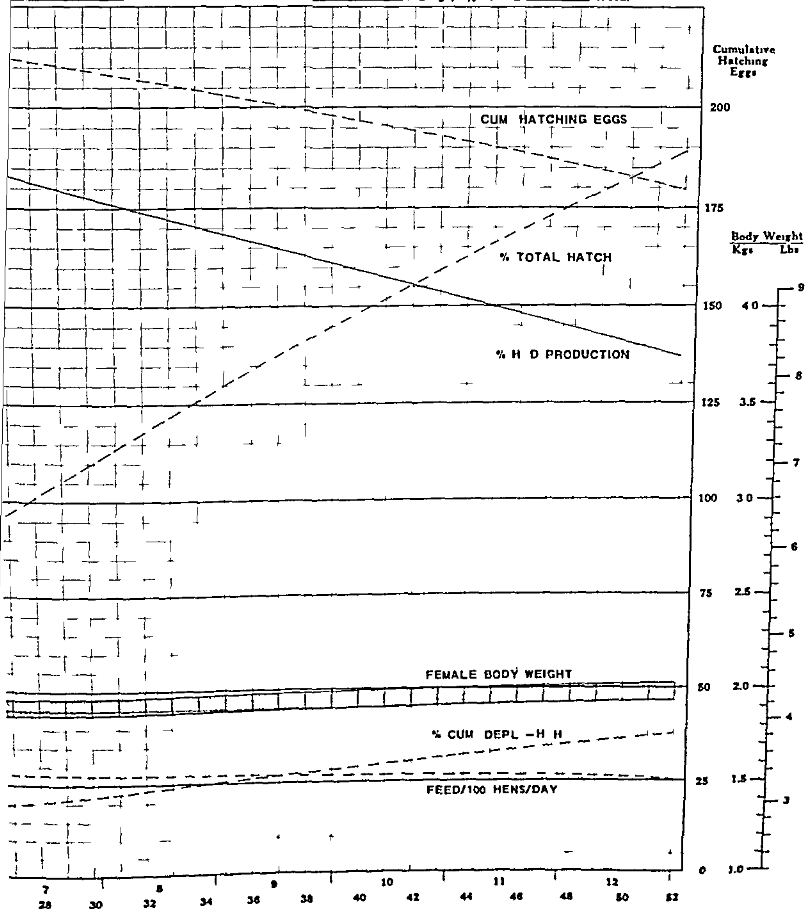
Hatch Date ________ Age, 5% Prod ________ Week



PRODUCTION GRAPH

ES FARM
TION RECORD 22 x 66 (LEGHORN) #2119

Hatch Date ____________ Age, 5% Prod ________ Weeks



PRODUCTION GRAPH

ARBOR A
FLOCK PRODU

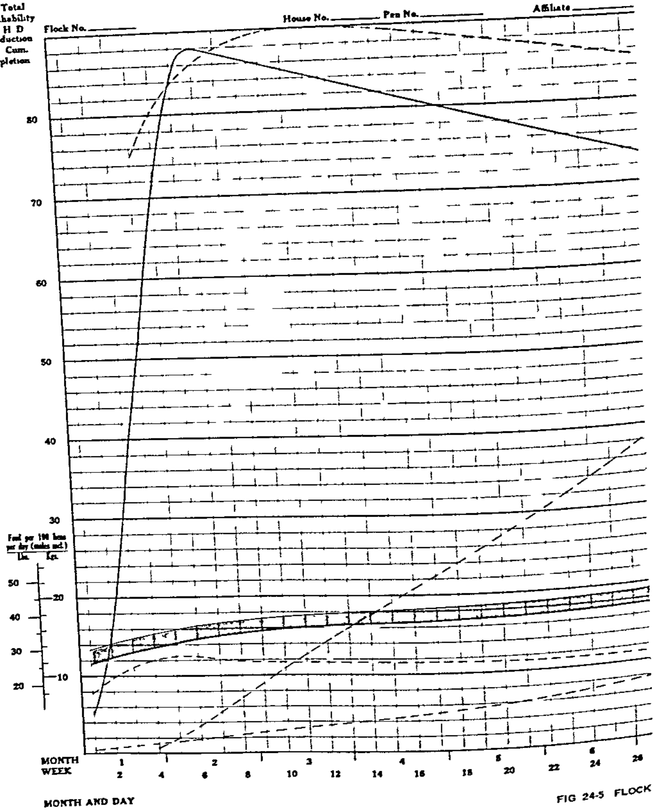


FIG 24-5 FLOCK

FOR FLOCKS COMPLETING 1ST PERIOD OF EGG PRODUCTION

HOUSE RECORD RECAP

AFFILIATE ______________________

MATING MALE ____________ X FEMALE ____________ FLOCK ____________ HOUSE ____________

PPLO STATUS OF FLOCK (+ OR −) ____________

GROWING PERIOD

1	DATE CHICKS STARTED (Spell the month)	________
2	NUMBER OF PULLET CHICKS STARTED INCLUDING EXTRAS	________
3	% CUMULATIVE PULLET DEPLETION TO 5% EGG PRODUCTION	________ %
4	NUMBER OF COCKEREL CHICKS STARTED INCLUDING EXTRAS	________
5	% CUMULATIVE COCKEREL DEPLETION TO 5% PULLET EGG PRODUCTION	________ %
6	FEED CONSUMED PER PULLET TO 5% H D PRODUCTION (MALES INCL.) (Total feed consumed by males and females in flock divided by number females alive at 5% production. Indicate lbs. or kilos)	________

1ST LAYING PERIOD

		ACTUAL	STANDARD
7	AGE PULLETS REACHED 5% H D EGG PRODUCTION (WEEKS)	wks	
8	NUMBER PULLETS AT 5% H D EGG PRODUCTION		
9	% PULLETS AT 5% H D PRODUCTION OF THOSE STARTED	%	%
10	ACTUAL DATE FLOCK COMPLETED 1ST LAYING PERIOD (Spell the month)		
11	NUMBER WEEKS IN EGG PRODUCTION		
12	% CUMULATIVE FEMALE DEPLETION	%	%
13	% CUMULATIVE MALE DEPLETION	%	%
14	TOTAL NUMBER OF EGGS PRODUCED BY FLOCK		
15	TOTAL EGGS PRODUCED PER HEN HOUSED (Line 14 ÷ line 8)		
16	YOUR HATCHING EGG MINIMUM WEIGHT (OZS. DOZ. OR GMS./EACH)		
17	TOTAL NUMBER HATCHING EGGS PRODUCED BY FLOCK		
18	HATCHING EGGS PRODUCED PER HEN HOUSED (Line 17 ÷ line 8)		
19	AVERAGE % TOTAL HATCHABILITY FOR LAYING PERIOD	%	%
20	POUNDS OR KILOS FEED CONSUMED PER DOZEN TOTAL EGGS PRODUCED (MALES INCL.)		

COMMENTS

DATE ______________________ PREPARED BY ______________________

FIG. 24-6 HOUSE RECORD RECAP

should include the growing period and the egg production cycle. An example is given in Fig. 24.6 for breeder flocks, and is self-explanatory. Notice that a column is available for inserting the standard figures when they are available.

PATTERNS OF EGG PRODUCTION

This subject deals with the relationship between weekly hen-day egg production and total egg production for the entire laying cycle. It is a well known fact that when egg production begins in a flock, the number of eggs produced increases rapidly during the first 5 or 6 weeks, then drops off at a constant rate during the remainder of the laying period. Egg production on a weekly basis is usually expressed in terms of percent; and to divorce production from mortality, hen-day percentages are given rather than hen-housed figures.

When these weekly hen-day egg production percentage figures are plotted on graph paper and the points connected, as in Fig. 24.5, a curve develops that is typical for all lines and breeds, although the percentage at the peak of production and the slope of the descending portion of the curve will vary for each strain of birds. Evidently the shape of this curve is an inherited characteristic, for not only do strains differ in their expression, but individual hens within a flock behave differently. However, geneticists have done little to alter the slopes of these curves within their strains of chickens. Most variations come indirectly as the result of improving egg production, egg size, shell quality, interior egg quality, and persistence of lay.

Production Curve and Associated Factors

Once a typical or standard egg production curve is developed for a particular strain of birds according to its genetic derivation, changes come only through selection for other genetic traits. For example, if a geneticist wanted to increase the egg production in a strain of chickens it would be necessary to have the birds peak higher, and to have them lay at a slightly higher rate after the peak was reached. As egg size has a negative genetic correlation with egg production, any increase of egg size within the strain would be associated with lower egg production; therefore, the peak of production and egg production after the peak would be slightly lower.

How to Construct a Production Curve

In constructing a production curve, a uniform percentage figure of egg production must be used as the starting point. The week in which the flock attains 5% hen-day egg production on any one day is used in this text as the *first week of production.* To wait until the flock is in higher production before starting the curves gives an erroneous picture.

With a *normal* curve for any line of birds certain facts are evident:

(1) *Rapid increase in egg production:* Egg production increases rapidly after sexual maturity until it reaches a peak in 5 or 6 weeks. This time interval may be altered by management. The more feed restriction during the growing period, the sooner the peak is reached. Out-of-season flocks peak later than in-season flocks. Birds grown on a light-restriction program peak sooner than those with no light control.

(2) *The peak of egg production is abrupt* Percentage *flock* egg production is nothing more than a mathematical average of the percentage figure for each hen in the flock If all birds peaked on the same day, the peak of the production curve would be very abrupt But flocks are not uniform in sexual maturity Thus, some birds start egg production sooner than others and reach their peak of production sooner If the flock is "normal" in respect to the age at which sexual maturity (first egg) is reached, the peak of the production curve will be fairly abrupt But if the flock is not uniform, the peak will not be abrupt, rather, the curve will take on an "arched" form Associated with a decrease in uniformity at sexual maturity and peak of production are such factors as full feeding rather than controlled feeding during the growing period, out-of season flocks, and lack of a light-control program during growing

(3) *Descending curve a straight line* In the normal or standard curve the percentages show an equal drop each week after the peak is reached, but the rate of drop is a genetic response varying with each breed and line When management is good, the actual productivity of the flock will coincide with this line, but when it is poor, when there are stresses, or when the environmental temperature is high, the rate of weekly decrease will be greater than the genetic standard, flocks will do poorly at the end of the laying period

Flocks Must Come Into Production Fast

For a flock to attain its standard peak of egg production, the birds must reach the peak quickly Eggs "lost" during this period will not be regained later in the production cycle In all probability this is the most critical period of egg production It is a time when management must be aware of the pitfalls that await annual egg production

Double-or nothing rule of thumb Although the statement is descriptive only, it does mean that flocks starting their production period must double their percentage hen-day egg production each week prior to reaching the peak, e g , 5, 10, 20, 40, and 80% Unless the increase is this rapid there is a problem, and emphasis must be placed on eliminating the difficulty immediately To wait is disastrous

Peak Egg Production Associated with Annual Production

If the flock manager is to attain the bred in ability of the strain of birds to produce a standard number of eggs, birds must peak at the peak point on the production curve Flocks which do not reach high production at their peak seldom make up for this loss of eggs later If the standard for a flock of commercial Leghorn pullets is 253 eggs in 52 weeks of lay on a hen-day basis, and the peak production is 92%, the flock is unlikely to produce 253 eggs unless the peak percentage is reached In fact, the correlation between peak egg production is very close For instance, if the flock peaked at 83% instead of 92%, the chances are great that total egg production will decrease by the same percentage

Example 83% is approximately 90% of 92% 90% of 253 eggs (hen-day) is approximately 228 eggs

Poor Peak Production Cannot Be Made Up Later

The old adage that if the flock does not peak high it will make up the egg production later in the laying year is unfounded. Although there are environmental and management conditions that affect the relative slope of the downcurve during this period, most flocks will show weekly decreases in egg production that are identical with the decreases exemplified by the normal or standard flock. Therefore, if the flock lays at 10% below the standard production at the peak, it will continue to stay 10% below the standard rate throughout the rest of the laying period.

Break On The Upswing

When a flock shows a *break* in production due to a pronounced stress, disease, or other factor, egg production does not continue at the normal rate, but decreases rapidly, and it may be days or weeks before the flock returns to "normal." When these breaks come during the first 5 or 6 weeks of egg production, the break is on the "upswing" portion of the production curve. These are most disastrous; flocks never reach their standard peak and eggs are "lost," never to be regained. The flock will not be uniform after recovery, and the production curve will take on an "arched" appearance before it begins its downswing. When flock recovery is made, the best the flock can do is to return to an egg production percentage commensurate with the standard percentage egg production on the week of recovery. That is the bred-in ability of the flock to produce at a given rate for that particular week of egg production.

Break On The Downswing

If some stress causes a drop in egg production after the peak is reached, it is said to be a *break on the downswing* of the production curve. Breaks during this period usually are not as severe as those on the upswing period. If the egg production of the flock has been normal and at standard before a break on the downswing, the egg production after recovery from the break can only attain a percentage figure identical with the *standard* percentage figure. Production will not return to the same figure that it was before the break. Again, the genetic potentiality is for a flock to lay at a given percentage according to the specific week of egg production.

Manager Must Study the Curves

As the stock market analyst studies his charts, so must the poultry farm manager study his egg production graphs. In this way he will be able to prevent many production difficulties before they become an actuality. Graph your production figures. Graphs will give you a much better picture of laying house performance than the figures themselves.

Digestion and Metabolism

The following several chapters are devoted to the feeding of chickens It is not the intention to detail the many facets of the subjects of digestion, metabolism, and feed formulation, but rather to treat the subject of feeding from a practical standpoint The technical aspects of nutrition may be pursued in many textbooks and scientific articles on the subject Only a brief summary will be given here

Good poultry nutrition first involves a correct feed formula for the particular type and age of chicken to be fed Practically all the nutrients the bird receives must be incorporated in the feed it eats Not only must the nutritional demands be met, but care must be taken to see that excesses of any ingredient or compound are not fed, not only for nutritional reasons, but to provide a diet that is economical as well

However, poultry feeding goes far beyond a correct feed formula When to feed, how much to feed, and when to make changes in the daily feeding procedures seem to be just as important Although many poultry rations are self fed—that is, feed is kept before the chickens at all times and they eat at will—the present procedure in many instances is to curtail the bird's feed intake so as to produce a better bird, and to produce it more economically Because of this, there are day-to-day decisions to be made, in order to give the bird the nutrients it needs, but no more Probably more failures in feeding are now the result of improper administration of a given feed than of failures due to inadequate feed formulation From the poultryman's point of view, FEED MANAGEMENT is a study of the basic nutritional requirements of the chicken and how to feed a given formula correctly and economically

DIGESTION

A large percentage of the feed ingredients consumed by a chicken is in a form that necessitates chemical and other reactions before it can be utilized by the bird The alimentary canal is a long tube through which the food passes while these reactions take place Therefore, *digestion* refers to those changes that occur in the alimentary canal to make it possible for the feed to be absorbed through the intestinal wall and enter the bloodstream The chemical reactions taking place during digestion are associated with breaking down large, complex molecules of protein, carbohydrate, and fat into simpler components capable of absorption

Within certain sections of the digestive tract, chemicals are produced to facilitate the digestive process These are known as *enzymes*, and each of the several types has a specific function in producing the necessary chemical reaction Enzymes are catalysts produced by living cells to aid certain chemical reactions without entering into them All enzymes are conjugated proteins

Other chemicals are secreted to alter the acidity or alkalinity of the tract so that the chemical reactions may be expedited Bacteria play a certain role All in all, the digestive process is quick, continuous, and constant For the most part, the processes are the same in a young chick as they are in a laying hen

Basic Nutritional Materials

All animals and birds require certain basic feed constituents to be able to live, grow, and reproduce. This list includes:

(1) proteins;
(2) carbohydrates;
(3) fats,
(4) minerals,
(5) water;
(6) vitamins.

The digestion of these dietary components varies greatly and each section of the digestive tract is responsible for its own processes See Chapter 2.

Mouth

Secreted in the mouth of the chicken is a fluid known as *saliva*. It is very slightly alkaline and contains the enzyme *ptyalin* which has the capacity to hydrolyze starch, converting it to sugars However, food is held but a short time in the mouth of the chicken and the hydrolysis in this area is minor.

Crop

After leaving the mouth, food continues down the gullet to the crop, a reservoir for storage The food material remains here for varying lengths of time depending on its particle size, on the amount consumed, and on the quantity of material in the gizzard. In the crop the feed particles are softened, and ptyalin continues to hydrolyze the starches

Proventriculus

The proventriculus is a bulbous organ situated just before the gizzard, and is sometimes known as the *glandular stomach* It is here that the gastric enzyme, pepsin, is produced, along with hydrochloric acid The pepsin acts to break down the complex protein molecules, the hydrochloric acid changes the contents of the digestive tract from alkaline to acid and aids protein digestion.

The proventriculus is small and holds little food material, food passes quickly through it to the gizzard. Because food is held in the proventriculus for such a short time, little or no actual digestion takes place here. Rather, the chemical reactions due to the gastric solutions are consummated in the gizzard

Gizzard

The gizzard is a highly muscular portion of the alimentary tract It is here that large particles of feed material undergo mechanical grinding, usually in the presence of "grit" in the form of sand, gravel, granite, or other abrasive to help facilitate the process. Although highly variable, the contents comprise about 50% water when in the gizzard Digestion continues as the result of the secretions of the proventriculus

Small Intestine

The foremost portion of the small intestine is known as the *duodenum* It takes the form of a loop known as the *duodenal loop*, imbedded within the loop is the *pancreas*, a gland which empties its secretions into the intestine. The pancreas

produces *enzymes* These, along with other enzymes, continue the process of digestion in the duodenum, although most of the absorption takes place in the next section of the small intestine, the *jejunum*

Bile is secreted by the liver and flows into the duodenum as a thick green material It does not contain enzymes, but helps emulsify the fats and plays a part in other digestive processes

When the feed contents leave the gizzard they are slightly acid as the result of the hydrochloric acid secreted in the proventriculus, but the contents become alkaline as they pass through the *jejunum* and the *ileum*, the next two sections of the small intestine, and through the large intestine, which is quite short in the chicken

Relatively speaking, little digestion takes place until the food reaches the small intestine Here, most of it is completed

Large Intestine

Some of the processes of digestion may continue in the large intestine, although *no enzymes are secreted here, any digestion is merely a continuation of processes* initiated in the small intestine

Water moves in and out of the large intestine, but outward transfer predominates, to bring the intestinal contents into a more solid state This movement of water is related to conditions associated with dehydration and edema of the tissues *Dehydration* is a condition produced as the result of a loss of sodium or potassium from the muscle cells Retention of water produces *edema*, a condition arising when too much salt is consumed, and the body tries to dilute the salt in the cells of the tissues and in the space between the cells by osmosis Both dehydration and edema of the tissues affect the transfer of water through the walls of the large intestine

Ceca

At the juncture of the small and large intestines are two "blind" pouches, called the *ceca* Fermentation and some digestion take place here Fermentation is instrumental in digesting the very small quantity of crude fiber the chicken is able to utilize

Endpoints of Digestion

The endpoints of digestion may be briefly described

Protein Proteins must be broken down into *amino acids* in order to pass the intestinal wall Proteins as generally known in the Plant and Animal Kingdoms, are composed of various combinations of the 22 amino acids But each protein does not contain all 22, nor is the quantity of each acid constant in each Therefore, there are many combinations of amino acids that comprise proteins the list runs into the hundreds Furthermore, proteins are often combined with carbohydrates, fats, and minerals, to add to the many combinations Consumed proteins not only vary in their amino acid relationship, but in their digestibility For instance, fish protein is more digestible than protein from blood

Carbohydrate Carbohydrates are complex chemical structures composed of starches, celluloses, pentosans, some sugars, and other forms The carbo

hydrates undergo hydrolysis during the course of digestion, reducing the complex structures to *maltose* and finally to *glucose*. The latter is easily absorbed from the intestine and is the main form in which simple sugars enter the bloodstream.

Fat: Fats cannot be absorbed unless they are at least partially soluble in water. Digestion includes the formation of fatty acids and glycerols through the fat-splitting enzyme. The bile material is helpful in providing this reaction, and fats are absorbed to enter the lymphatic system, thence to the portal system by way of the liver.

Although fats are high in calories, there is no relationship between their original form and their available energy. The makeup of the fat and the age of the bird enter into the relationship. Beef tallow, for example, is a better fat source for older birds than for young chicks. The role of fat digestion is not the final answer either; it is but the first step in making the energy of consumed fat available for productive processes.

Crude fiber: In ruminants and some other animals, crude fiber forms an important part of the diet. However, the chicken is not endowed with processes necessary to digest any quantity; only a token amount of the crude fiber in the feed is digested and most of that by fermentation. Thus, for all practical purposes, crude fiber in feed is not utilized by the chicken.

Minerals: Minerals cannot be said to undergo digestion; they are absorbed from the intestinal tract in the same form as they are fed; but this solubility is related to their absorption.

Vitamins: Many vitamins occur in combinations that prevent absorption through the intestinal wall; they must undergo a type of digestion, or at least change, to enable them to pass into the bloodstream. The diet is not the sole source of all vitamins. Vitamin D, for instance, is synthesized at the skin surface by the ultraviolet radiation in sunlight, but it may also be included in the diet.

Drugs and antibiotics: Many drugs and antibiotics are administered to chickens, either through the feed they eat or the water they drink, to enter the digestive tract. Some of these are of nutritional value, as they produce an increase in growth or egg production, but most of them are used to suppress or regulate the growth of pathogenic organisms. In practically all cases, the drugs enter the bloodstream in their original form. However, there are variations between the amount absorbed and that consumed. Some drugs are absorbed almost completely, while others show little or no penetration of the intestinal wall. The choice of a drug for medicinal purposes is often governed by the part of the body requiring it. When the drug is used to treat intestinal disorders it is better that it not be absorbed; when it must reach the bloodstream and tissues, it should have a high absorption quotient.

Total Digestible Nutrients

All the food material that is consumed is not digested. The percentage is quite consistent with each feed ingredient, although there are some variations according to the age of the bird. That portion of the food that does not pass the intestinal wall is excreted in the fecal material, though not necessarily in its original form.

cule, after which the nitrogen is excreted by the kidneys most generally in the form of *uric acid*; this is found in small quantities in the urine of most mammals, but in high amounts in the excrement of chickens in the form of *urates.*

Proteins are essential for life; the actual need by the bird is the result of its demand for the amino acids. Some amino acids can be formed in the body, but when their production is low, or they are not made at all, they are said to be *essential amino acids.* The inadequacy must be made up through dietary ingestion. When body production of an amino acid is sufficient for normal physiological processes, it is included in the group known as *nonessential amino acids.* Of the 22 amino acids, about 12 are classified as essential, and must be incorporated in the ration either separately or as a component of a feed.

Carbohydrate Metabolism

A portion of the glucose entering the bloodstream is used to produce energy. During the process, body heat is generated. The procedure is relatively quick; there is a close correlation between feed consumption and energy produced. The bulk of the glucose and a few other simple sugars are first converted to *glycogen* by the liver. Glycogen has the common name of *animal starch.* It is in the form of glycogen that excesses of simple sugars are stored in the liver and on occasion in some other parts of the body. But the storage capacity in this form is not great. When there is a demand for additional glucose, the stored glycogen is converted to glucose, in which form the sugar is released into the bloodstream. The bird has a governing mechanism to keep the level of glucose in the bloodstream nearly constant so that the supply is uniform. When the storage capacity of the bird for glycogen reaches its maximum, additional glucose in the bloodstream is quickly converted to fat to keep the blood at its tolerance level; the fat is deposited in the fat cells at various locations in the bird.

Fat Metabolism

The metabolism of fats is a process by which the fatty acids are converted and used for energy, egg production, or stored as body fat. Stored fats are species-specific, that is, the consistency, as indicated by their texture, melting point, etc., varies according to the bird or the animal. The relationship between the fat consumed and the stored fat in the chicken can be altered only when large amounts of fat are consumed.

Unlike some other nutrients, fat is not excreted either in an original form or as by-products. Excesses can only be deposited in the fat cells. If the carbohydrate or fat consumed is greater than that required by the bird, deposits of fat continue; seemingly there is no limit. If the energy portion of the diet is lowered below the amount necessary for body processes, the stored fat will be called upon to make up the difference; and the fat deposits decrease.

Mineral Metabolism

Many minerals are necessary for the physiological well-being of the individual. For example, calcium is required in relatively large quantities in bone formation and in the deposition of eggshells, while another, phosphorus, is especially needed for the production of bones. Other minerals fall in the classification of *trace minerals*; since their relative requirement is small, only trace amounts are required. In this group are copper, zinc, iron, manganese, selenium, etc. Another group

As an example of this variability, corn has a digestibility of about 80%, wheat middlings 48% and alfalfa meal about 25%

Time Required For Food to Pass Through Alimentary Tract

Many factors affect the flow of food through the alimentary tract The "call" of the gizzard for more food will determine the length of time that feed remains in the crop Sometimes it may be only minutes, at others it may be several hours If the feed is in fine form it can pass the gizzard in a very short time, but if it is coarse it must first be broken down into small particles before it can enter the intestines Some feed may leave the gizzard after a few minutes, in other cases, as with whole grains, the grinding action may take hours

Actually, the entire process of digestion is rapid If the alimentary tract is empty, feed will pass through it in about $3^1/_2$ hours When feeding is more or less continuous, the entire process of transfer will take about 12 hours Digestion is more rapid in a laying hen than in one that is not laying The transfer is quicker during daylight hours than at night

METABOLISM

Metabolism is a term used to denote those chemical changes in food components that occur after digestion and absorption Since the various portions of feed (protein, carbohydrates, fats, vitamins, and minerals) have been converted to structures capable of absorption during digestion, they must be reconverted to complex forms before they are of value to the bird For the tissues of the body to be able to utilize the simpler compounds carried to them by the blood system, therefore, further chemical reactions must take place By these additional processes energy is developed, heat is liberated, and many endproducts not of value are eliminated through the kidneys

How Food Material is Utilized in the Body

The body has almost an hourly need for certain food materials in order to carry out its physiological processes These materials perform the following general functions

(1) maintenance of life,
(2) growth,
(3) production of feathers,
(4) egg production,
(5) deposition of fat

To carry out these functions, food must be metabolized As the subject is detailed and scientific, only a general approach will be presented here, to familiarize the reader with the metabolic processes involved

Protein Metabolism

Once the amino acids enter the bloodstream they are transferred to the various tissues of the body Here the cells use them in many ways, such as for the repair of tissue structure, new tissues, egg production, etc , and for the rebuilding of various complex protein structures However, all the amino acids entering the bloodstream may not be necessary to manufacture a type of protein for a particular bird at a particular time Excesses of amino acids may be used for energy through a process of deamination, which splits off the nitrogen from the mole-

cule, after which the nitrogen is excreted by the kidneys most generally in the form of *uric acid*; this is found in small quantities in the urine of most mammals, but in high amounts in the excrement of chickens in the form of *urates*.

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Minerals are not metabolized in the strict sense, rather they are incorporated as a part of certain protein or enzyme molecules In many instances, chemical reactions which produce these molecules cannot take place without the mineral Therefore, many minerals are an important part of the metabolic process, although sometimes indirectly In some cases a small amount of a trace mineral is absolutely essential, but an excess leads to difficulties, as with selenium

Water Metabolism

Probably none of the items consumed by the bird is more important to its physiological processes than water Not only does the bird derive its supply from normal water and the moisture in the feed, but water is one of the end points of metabolic reactions

Hormones

Hormones are body chemicals generated by specialized cells, when transported to other cells in the body hormones influence their activity Probably the most common example is the hormones of the sex glands, which produce the differences associated with maleness and femaleness Although both sexes produce a quantity of male and female hormone one or the other predominates to produce the sex variation When male chickens are castrated, the production of the male hormone is reduced and the shape of certain feathers associated with a male are altered to female type feathers, as a result of the female hormone

Some hormones are secreted by the pituitary gland, some by the adrenals, one by the thyroid, etc Some have an effect on digestion, some on metabolism, and others on reproductive performance

Estrogens The female hormones are known as estrogens Certain estrogens have a bearing on fat deposition *Diethylstilbestrol* (DES) is one commonly used during the production of broilers and roasters to increase and alter the fat content of the males and females A small pellet of DES is embedded under the skin of the neck

Caution The use of DES is illegal in some countries Check with authorities before using it

Thyroxine Thyroxine is the chief secretion of the thyroid gland Iodine in the ration undergoes digestion to form iodide Once in the bloodstream it finds its seat in the thyroid gland, where it is changed to organic iodine Thyroxine contains the iodine so necessary for certain body reactions When there is a deficiency of iodine in the diet, the thyroid increases in size in its endeavor to increase the production of thyroxine A goiter is produ

Major Feed Ingredients

It is common practice to feed the chicken a ration that is a mixture of economically available ingredients so as to provide every known nutritional need in quantities necessary for its daily well-being. The science of determining these daily requirements is one of vast proportions. The fact that the chicken grows and reproduces rapidly and requires a small amount of space has made it an excellent laboratory animal; the knowledge of poultry nutrition has been greatly enhanced because of this.

Commercial poultry rations today are known as *complete rations*; that is, they contain all the essential ingredients for the bird to do a job well, whether it be in growth, feather renewal, egg production, or the production of meat. For the most part the bird, being closely confined to its quarters, has no other source of food material. What it needs it must get from the feed it is given each day.

Certain parts of this feed come from the common and major feed ingredients such as cereal grains, protein and fat supplements, certain mill by-products, and the major minerals. But in most cases, a mixture of these ingredients would not satisfy the bird's nutritional requirement, nor do it economically. Certain vitamins, minerals, by-products, and other ingredients must be added to "balance" the diet. This chapter deals with the major feed components; Chapter 27 includes the others.

Barley

Barley is produced abundantly in some areas and is used in many poultry rations as a fine-ground ingredient. Compared with corn, it contains about 75% as much energy and 3 times as much fiber. Therefore, its use is limited, especially in feed mixtures that must be high in energy and low in fiber. Although the fiber of barley is practically indigestible, the grain may be soaked or treated with enzymes to improve its qualities. The cost of energy in normal barley must be considered when it is to be substituted for other energy-carrying cereals. In many areas it would be uneconomical to use barley.

Buckwheat

Buckwheat is seldom used as a poultry feed because of its limited production and its unpalatability. Ground buckwheat may be used to replace up to 15% of the cereal grain portion of the ration.

Cassava

Cassava or cassava root is produced in abundance in many tropical areas under a variety of names: mandioca, manioca, tapioca, yucca, and manioc. By enzymic action the roots release a poisonous compound, prussic acid. Special washing is necessary to make the root edible. In ground form, cassava root may replace up to half the cereal grains in a ration, if its inadequate content of methionine and protein is provided for.

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Other hormones Many other hormones play a part in keeping the body functioning properly The hormones of the parathyroid are involved with maintaining the calcium level in the blood, prolactin is responsible for broodiness, secretions of the adrenals have a bearing on carbohydrate metabolism, and the islets of Langerhans secrete insulin so important in keeping the level of blood sugar constant There are many more, some of which work together to produce their effect

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Corn (Maize)

In most areas, corn is the predominate source of energy in poultry feeds, mainly because of its abundance, economy, and high digestibility Corn is, however, a variable cereal grain, and in many countries is sold by "grade" which gives an indication of its moisture content, weight, kernel composition, and the presence of foreign material Corn also has a variable protein content, from 8 to nearly 11% Most corn is now the result of hybrid breeding in an endeavor to produce plants adaptable to certain climates, rainfall, and soil composition

Yellow corn Yellow corn contains an abundant quantity of carotenoid pigments called xanthophylls, which also are responsible for the yellow pigment in the fat deposits of chickens and in egg yolk Yellow corn is a fair source of vitamin A activity, but storage tends to reduce the vitamin content by as much as 30%

White corn White corn is similar to yellow corn in most respects except that it contains little xanthophyll and has practically no vitamin A activity

High lysine corn A special hybrid corn has been developed that is high in the amino acid lysine The hybrid is specifically known as *opaque 2*, after the gene responsible This corn contains about 11 5% total protein, about 35% more than normal dent corn The amount of lysine is also about 35% greater than the lysine content of normal corn

Millet (Proso)

Proso millet is grown abundantly in a few areas There are several varieties In general, millet has an energy content nearly that of corn, but is fed in combination with corn or milo in broiler rations Corn, milo, oats, or barley are combined with millet in growing and laying rations It should be coarsely ground

Molasses

Usually, molasses is a by product of the cane sugar and beet sugar industries Beet molasses contains about 6% protein, cane molasses, about 3% Although both are relatively high in energy, molasses is used more in poultry feeds to prevent dustiness and in the treatment of blue comb disease because of its sugar content Amounts higher than 5% of the rations produce a laxative condition, but as much as 10% may be incorporated without creating a great problem

Oats

Although excellent as a feed for chickens, oats are limited in their use in poultry formulas They contain a large amount of fiber because of their husk, and are therefore low in energy With a fiber content of about 12% compared with 2% for corn, oats contain only about 75% as much energy as corn Because of this, oats cannot be used in any quantity in a high-energy broiler ration, their value lies in growing, laying, and breeder feeds When incorporated in a mash, oats should be finely ground in order to pulverize the hulls thoroughly

Oat hulls. These contain about 30% crude fiber and are often used as a "filler" in low-energy diets

Rice

Because of new rice varieties that produce greater yields, surpluses of rice are developing in some countries. These surpluses, along with broken and undergrade rice, can effectively be used in poultry rations. In some areas of the world the price may be competitive with other cereal grains.

Rough rice: This name is applied to the entire rice kernel, including hull. Compared with corn it is high in fiber and low in energy.

Milled rice: This includes whole-kernel, broken, and undergrade processed rice. Its feeding value is quite comparable with corn except that it has no Vitamin A activity nor any pigmenting qualities.

Rye

Rye has a property that produces a laxative effect when fed to chickens; the droppings become sticky and adhere to the feet of the birds. Furthermore, chickens do not like the taste of rye. When they have a choice between kernel rye and other whole-kernel cereals, they will eat practically no rye. But rye may be ground and mixed in the feed provided it does not replace more than one-fourth the cereal grains in the ration for young chicks, nor more than one-third for older birds. It has a high energy content.

Sorghums

There are several sorghum grains, but kafir and milo are the two generally used in poultry rations. These are grown extensively in many areas and make up an important part of the poultry feed. Although somewhat unpalatable in ground form, they may be used effectively to replace two-thirds of the cereal grain portion of most rations. If the feed is pelleted, the percentage can be higher. Kafir and milo are quite comparable with corn in feeding value except that they have no vitamin A activity nor any pigmenting properties.

Wheat

Whole wheat has an energy relationship analogous to corn and contains a higher percentage of protein. The protein may vary between 10 and 13%, depending on the type of wheat and the area where grown. However, wheat is practical in poultry diets only when it is available in quantity and will provide an economical source of energy. Because of its great use in human diets it generally carries a high price.

Wheat is gelatinous, and when ground and used in high percentages, it has a tendency to "paste" on the beaks of birds. The pasting may sometimes produce *beak necrosis.* If the wheat incorporated in a poultry mash is coarsely ground, or if the feed is pelleted, most of the difficulty is overcome. Wheat has no vitamin A activity nor pigmenting properties. As far as metabolizable energy is concerned, 109 lb of wheat are equivalent to 100 lb of corn.

MILL BY-PRODUCTS

Hominy Feed

This is a by-product mixture, the result of producing pearl hominy. The product used for poultry feeding should not be the result of solvent extraction, as this re-

moves most of the fat, and thus reduces the energy value to a low level Good hominy feed should contain at least 1350 calories of metabolizable energy per pound (2970 cal ME/kg)

Rice Bran

Rice bran is composed mainly of the pericarp and germ of rice as a by product of the milling of raw rice to produce an edible product It contains about 13% protein, slightly less than wheat bran, and about half as much energy as corn The high fat content of rice bran (13 to 15%) makes it a fairly good poultry feed

Rice Hulls

Rice hulls have little nutritional value, but sometimes are used as a "filler" to build low-energy rations

Wheat Byproducts

Wheat bran Wheat bran is composed of the outer layer of the wheat kernel It is one of the by products of wheat milling and contains about 16% protein and 545 calories of ME per pound (1200 cal ME/kg) It is seldom used in poultry rations today

Wheat middlings, shorts These are a mixture of milling by products including the finer particles of bran, germ, flour, etc Wheat shorts contain slightly more crude protein and more metabolizable energy than wheat middlings

PROTEINS OF ANIMAL ORIGIN

Blood Meal

This protein supplement, composed of ground dried blood, contains about 80% crude protein and is an excellent source of the amino acid lysine, of which about two thirds is available to the bird But blood meal is otherwise deficient in quality protein, and only token amounts should be included in the ration if maximum growth and egg response are to be realized

Liver Meal

Liver meal is an excellent animal protein supplement but is in short supply and expensive Because of this, it is seldom used except in special laboratory diets

Meat Products

Two meat by products are of value in poultry feed formulation, although their use has largely given way to vegetable protein supplements in the ration

Meat scrap This is a dry rendered product made from animal flesh and tissues It must be guaranteed low in phosphorus to show that little or no bone was incorporated It contains about 50 to 55% protein Meat scrap is used in moderate amounts in many poultry rations, but its amino acid value is limited Usually 5% is a maximum when efficiency of the ration is needed Otherwise, up to 10% may be included

Meat and bone meal (scrap) This product is more readily available than meat scrap and is a good protein supplement It contains a relatively high percentage of ground bone, making it a carrier of calcium and phosphorus

It may be used up to 10% of the ration, but often it is restricted to about 5%.

Milk By-products

Most milk products used for poultry feeding are in dried form and are used in the mash, although some milks have been condensed to a thick consistency (27% solids) and fed separately. The quality of milk protein is excellent, and for years some milk by-products were incorporated in great amounts in poultry rations. However, large amounts are laxative, milk protein is comparatively expensive, and the products are not generally available in abundance. Seldom does a poultry ration contain more than 2% today, but several times this amount could be included under unusual circumstances. Dried skim milk and dried buttermilk, for all practical purposes, are equal in feeding value.

Dried skim milk: When the fats (cream) have been removed from whole milk and the remaining liquid (skim milk) is dried, the product is known as dried skim milk. It has about 32% protein.

Dried buttermilk: Drying the liquid remaining after the production of butter results in a product known as dried buttermilk, containing 32% protein.

Dried whey: In the production of cheese, the liquid portion remaining (whey) is dried. Dried whey contains a minimum of 65% lactose (milk sugar) and about 14% protein.

Poultry By-product Meal

This product consists of the ground, dry-rendered poultry offal including the heads, feet, intestines, etc., but excluding the feathers. It is an excellent protein source, but its short supply limits its use to from 1 to 2% in poultry rations.

Poultry Feather Meal (Hydrolyzed)

Hydrolyzed poultry feathers contain 80% and over of protein. However, the protein is high in cystine and deficient in the amino acids methionine, tryptophan, and lysine. Feather meal must be used sparingly in the ration, with thought given to its deficiencies.

PROTEINS OF FISH ORIGIN

There are many types of protein supplements derived from fish, the variations arising from the many types of fish and the part of the fish used in producing the meals. The number also is increased because of the four different methods of processing:

(1) sun-dried;
(2) vacuum-dried;
(3) steam-dried;
(4) flame-dried.

Sun-dried fish meal is usually of low quality, and little flame-dried material is produced today.

Most fish meals get top priority as a source of good quality protein for poultry feeding because of their well-balanced amino acid content. But all fish meals are not equal in the makeup of amino acids nor in their digestibility. Broadly, fish meals may be grouped into two categories:

(1) *White fish meals* These are processed from the nonedible portions of tuna, cod, halibut, and other fish They are low in fat
(2) *Dark fish meals* These come from such fish as sardine, herring, menhaden, etc , and are usually high in fat

Fish meals vary in their content of crude protein from 55 to 75% Herring meal is high, for instance, menhaden and sardine meals, medium, while tuna meal is low

Protein efficiencies When the protein efficiency of casein is given a base rating of 100, the following variations will be derived from various fish meals

vacuum-dried white fish meals	104
steam-dried white fish meals	104
domestic sardine meals	94
Asiatic sardine meals	91
flame-dried menhaden fish meals	80

Antioxidant in manufacture Ethoxyquin is being added to many fish meal products to prevent oxidation of the product This materially improves the value of the meals and tends to smooth out the above variability in efficiencies

Salt in fish meals Associated with the method of salting fish to preserve them is the salt (NaCl) content of the resulting fish meal As salt produces a laxative effect in the chicken, the salt content of the various fish meals should be carefully determined

Pricing fish meals Because of their variability in protein content, many fish meals are priced on a *point system*, one point being equal to 1% crude protein on a ton basis

Example If a "point" of protein costs US$3 00, one ton (2,000 lb) of fish meal containing 70% protein would have a value of US$210 ($3 00 X 70)

Amount of fish meal in the diet Because of their relative high cost plus a usual shortage of supply, fish meals are confined to about 5% in broiler rations and about 2% in others

Fish flavor in meat and eggs The oil from fish carries a definite "fishy" taste and odor which are noticeably imparted to the poultry meat and eggs when the diet contains more than 8 to 10% fish meal

Fish solubles The wet processing procedure of producing fish meal leaves a water by product known as "stick" which may be condensed or dried The value of these products lies not in the fish protein, but in vitamin B_{12} and certain unidentified growth factors (UGF)

Shrimp Meal

A by product of shrimp processing, this product contains about 43 to 47% protein and is higher in calcium than fish meals

PROTEINS OF VEGETABLE ORIGIN

Except for the cereal grains, protein supplements of vegetable origin comprise the largest component of most poultry rations Soybean oil meal is most commonly used because of its available supply, good nutritional value, and relative

economy The aim of most nutritionists is to build a diet composed of corn and soybean oil meal, adding other ingredients only to make up for the deficiencies of this mixture

Raw seeds cannot be used efficiently Many of the vegetable protein supplements are derived from seeds produced by various plants However, such seeds in their raw form cannot be used satisfactorily by chickens The seed first must undergo heat or other treatment to eliminate certain toxic factors that have a pronounced detrimental effect on many body organs Treatment of the seed also increases its nutritional value

Corn Gluten

Corn gluten comes in two products

(1) *Corn gluten feed* This is that part of the corn remaining after extraction of most of the starch and germ when corn starch and syrup are made It contains about 22% protein

(2) *Corn gluten meal* The meal is similar to corn gluten feed, except that the bran portion of the corn kernel has been removed and this meal is usually used for poultry feeding Although a good vegetable protein, its main value lies in its ability to impart yellow coloring matter to the skin of the chicken and to the egg yolks it produces Corn gluten meal has a protein content of about 42%

Coconut (Copra) Oil Meal

This product is the result of grinding the portion remaining after a part of the oil has been extracted from the coconut Its average protein content is about 20% Evidently there is a great variability in coconuts, and some may contain a material toxic to chickens Ten percent of the diet seems the limit when certain amino acids are supplemented, although chickens will consume up to twice this amount

Corn Germ Meal

Ground corn germ cake is corn germ meal It contains about 18% protein and is seldom used in poultry feeds

Cottonseed Meal

This meal is generally available in many areas as the result of oil extraction of cottonseed The expeller process was first used, but in many instances it has given way to solvent extraction, which removes more oil from the seed, but leaves less in the meal

Although cottonseed meal is a vegetable protein of good quality with about 41% protein, it is inferior to soybean oil meal A dehulled cottonseed meal will carry 50% protein Neither should be used as the only vegetable protein source in the ration

Gossypol content Cottonseed oil contains gossypol in minute quantities, yet the amount in cottonseed meal is adequate to cause the production of eggs with pink to dark mottled yolks Gossypol is toxic and reduces growth and egg production These properties have led to the production of special cottonseed meals very low in gossypol and these are the products best used in quantity in laying rations They are sold as *degossypolized cottonseed meals*, containing less than 0 04% gossypol

Guar Meal

Guar is an annual legume and its seed is used for the production of special gums The meal contains a trypsin inhibitor which is destroyed by cooking The gum is a growth depressor when used in excess of 2% of the diet It also causes very sticky fecal material Normally, no more than 10 to 15% of the diet should be from guar meal

Linseed (Flax) Oil Meal

This product is unpalatable and is not generally suitable for poultry feeding, but in the absence of good vegetable protein supplements a modest amount could be incorporated in the ration

Peanut (Groundnut) Meal

Peanut meal is a good vegetable protein supplement and, where available, large amounts may be used in the ration It contains 45 to 47% protein, depending on the type of processing Although peanuts contain a trypsin inhibitor, it is destroyed in the heating process Peanut meal is best supplemented with some soybean oil meal

Rapeseed Meal

Rapeseed meal should be fed cautiously Although a good, well balanced product with 39% protein, it contains factors detrimental to the bird and its productivity At high levels, the meal causes liver degeneration and thyroid hypertrophy It should not make up more than 10% of the diet, and preferably only 5%

Safflower Seed Meal

This product has had long use in moderate amounts in poultry rations It is low in lysine but can be fed up to 5% of the ration during the first four weeks of a chick's life, and 10% thereafter Two products are generally available

(1) 42% protein product (dehulled),
(2) 20% protein product

Sesame Meal

This meal contains some 47% protein and except for its inadequacy of lysine, is a good vegetable protein supplement However, its greatest value comes when supplemented with lysine and soybean oil meal Probably it should not make up over half the vegetable protein supplement portion of the diet, with a maximum of 15% of the total feed intake

Soybean Meal

The abundance of soybean production, and the high nutritional value of the processed bean have made it possible to use high percentages of the meal in most poultry rations Soybean meal is best supplemented with some animal or fish protein to make up its deficiencies of certain amino acids Synthetic amino acids also may be used Raw soybeans should not be fed They contain a trypsin inhibitor which must be destroyed by heat or other methods However, they may be heated to produce an edible product

Soybean meal is the by-product of oil extraction and contains from 43 to 50% protein, depending on the method of processing.

(1) *Expeller soybean meal:* This process does not remove as much valuable oil as solvent extraction, although the meal is nutritionally comparable. It has 43% protein.

(2) *Solvent soybean meal:* Solvent extraction of the oil from soybeans is predominantly in use today. The resulting meal is of excellent quality, although lower in fat than those resulting from expeller processing. The protein content is 46%.

(3) *Dehulled (solvent) soybean meal:* If the hull is removed, a meal higher in protein (50%), lower in fiber, and higher in energy can be produced. When high-energy diets such as broiler rations are required, dehulled meal is recommended.

Full-fat Soybeans

The low availability of the oil and the presence of a toxic factor in *raw* soybean seeds have made them unsuitable for poultry feeding. In the case of the young growing chick, raw soybeans will produce only about two-thirds the growth achieved with soybean oil meal.

Of late, however, renewed interest has been shown in trying to develop methods of heating raw whole-fat beans in order to eliminate the toxic factor and make the fat more available. Several methods of heat treatment have been used. Any procedure of heating has close limitations in regard to the amount of heat and length of the heating period; too much heat is more detrimental than too little. But when conditions are optimum, the growth value of such treated beans will approximate about 90% of that of soybean oil meal.

Sunflower Seed Meal

Where available, sunflower seed meal may be incorporated in poultry mashes up to a maximum of about 15%. The meal is sticky and may cause necrosis of the beak at higher levels. Pelleting a feed containing sunflower seed meal will prevent the stickiness at the beak. The meal has 41 to 47% protein.

GREEN, LEAFY PRODUCTS

Many grasses or legumes may be dried and fed to chickens as a source of carotene, xanthophyll, and an unknown growth factor. Some are high in vitamin K.

Alfalfa Products

There are several alfalfa products as the result of different methods of curing the hay and that portion of the plant used to make the meal.

(1) *Sun-cured alfalfa meal:* Originally, alfalfa hay was sun-cured and ground, but the product was highly variable.

(2) *Dehydrated alfalfa meal:* Alfalfa hays are now properly and uniformly dried artificially by heat, and then ground.

(3) *Dehydrated alfalfa leaf meal:* This is a product made from only the leaves of the alfalfa plant.

Analysis of alfalfa products The partial analysis of the above three products may be compared

Type	% Protein	% Fiber
Sun-cured alfalfa meal	13-15	28-30
Dehydrated alfalfa meal	17	25
Dehydrated alfalfa leaf meal	20	20

Vitamin A activity This activity is due to the precursor of vitamin A which is carotene, mostly in the beta form Dehydrated alfalfa products are much higher in carotene than sun-cured products But the carotene in the meal is easily lost through oxidation To prevent this, an antioxidant is used, or the meal is pelleted The pellets are ground prior to feed mixing

Alfalfa meals are measured by their vitamin A activity instead of their carotene content A meal of high quality should contain 100,000 units of vitamin A activity per pound

Green Grasses

In parts of the world where alfalfa is not grown, several green grasses are cut and dried as a substitute When these grasses are cut in their early stages of growth they provide an excellent source of many comparable nutrients

MINERALS

This section is devoted to sources of major minerals, calcium, phosphorus, sodium, and chlorine From a source standpoint, calcium and phosphorus are often associated together and sodium is combined with chlorine

Curaçao (Island) Rock Phosphate

This is a special rock phosphate containing about 15% phosphorus and 34% calcium

Dicalcium Phosphate

Dicalcium phosphate comes from rock phosphate or bone after special processing That derived from rock phosphate may contain an appreciable amount of fluorine, most of which must first be removed before the product is acceptable for poultry feeding Dicalcium phosphate contains approximately 18% phosphorus and 23% calcium

Rock Phosphate

This is ground phosphate rock, much of which is so high in fluorine that the raw rock must be defluorinated before it is fed Such a product is sold as *defluorinated rock phosphate* It contains about 13% phosphorus and 0.5% fluorine

Steamed Bone Meal ($Ca_3(PO_4)_2$)

This source of phosphorus comes from bones of animals It contains an appreciable amount of calcium Most products contain about 13% phosphorus and 26% calcium They also contain 12% protein

Limestone ($CaCO_3$)

Used as a source of feed calcium, limestone contains 38% calcium Care should be taken to use a limestone that is low in fluorine, sometimes known as *high-calcium limestone*

Oystershell ($CaCO_3$)

In most areas this is the main source of supplemental calcium, containing about 94% calcium carbonate (38% calcium)

Gypsum ($CaSO_4$ $2H_2O$)

There is every indication that the calcium in calcium sulphate is as available to the chicken as the calcium in calcium carbonate Gypsum contains about 22% calcium

Salt (NaCl)

Salt is a source of sodium and chlorine Although necessary in small quantities, either through other feed ingredients or free salt, large percentages in the diet increase water consumption and have a laxative effect Generally, no more than 0 5% of free salt is added to the poultry ration, in many instances, only 0 25%

Iodized salt In most of the areas of the world iodine must be added to the chicken's diet This is easily accomplished by adding iodine to the salt at a level of 0 007%, equivalent to 70 ppm

FATS AND OILS

Because of their high content of energy, relatively large amounts of fats or oils are added to some poultry rations, particularly those in the high-energy category As a side effect they reduce the dustiness of the mixed mash and improve its palatability Up to 8% of the mash as added fat is practical, but chickens can tolerate over twice this amount In many instances the practical use of fats or oils is determined by the price relationship between their energy and the energy derived from corn, milo, wheat, or rice When fat energy is cheap compared with the energy in any of these four, it is economical to use more fat or oil There are many feed grades of fats

(1) *Hard fats* Most of these are solid at room temperature and come from slaughtered cattle, they are known as *tallow*, and *lard*

(2) *Soft fats* These are semisolid, and have lower melting points, they are termed *greases*

(3) *Hydrolyzed animal fat* These are by products, mostly from the manufacture of soaps, and are sold as *hydrolyzed animal fat* or *hydrolyzed vegetable fat*

(4) *Vegetable oils* Oils in this group come from plants, such as coconut oil, etc , and are used as an energy source in poultry feeds

Value of fat types Not only are there several broad classifications of fats and oils, but in many cases each type of fat has several grades

Antioxidants in fats For preservation purposes and to prevent rancidity, antioxidants sometimes are added to fats and oils When fats or oils are to be kept for some time they should contain an antioxidant

Comparison of fats and oils The following shows the comparison between

corn and several fats and oils in respect to their metabolizable energy content and the utilization of the energy.

Ingredient	Approximate Calories of M.E. per Pound	% Utilization
Corn	1530	
Lard	4000	98
Hydrolyzed animal and vegetable fat	3400	72
Grease (yellow)	3400	84
Tallow (beef, feed grade)	3130	80

Vitamins and Trace Ingredients

Besides the carbohydrates, proteins, fats, and major minerals there are many nutrients in the chicken's diet that are necessary in much smaller quantities to enable the bird to live and produce meat and eggs economically and to reproduce efficiently. The list includes the vitamins, trace minerals, and certain other additives.

VITAMINS

Generally speaking, vitamins are organic chemical compounds that are usually not synthesized by the body cells, but that are necessary for maintenance, growth, and egg production. They are used in small amounts, and when they are deficient or absent from the diet, characteristic manifestations result. Many of them are enzyme-associated. There are 13 vitamins usually listed as necessary for the chicken; they occur in feedstuffs in varying quantities and in different combinations. All feedstuffs do not include all vitamins, and some contain a greater quantity of certain vitamins than of others. Some vitamins are produced by microorganisms of the intestinal tract, one by irradiation at the area of the bird's skin, while others are manufactured synthetically. As vitamins are definite chemical compounds, commercially produced vitamins are as valuable as those found in natural feedstuffs.

Vitamins are often segregated into two groups: (1) fat-soluble, meaning that they dissolve in fats or fat solvents, and (2) water-soluble, denoting that they dissolve in water.

Fat-soluble vitamins: The fat-soluble vitamins are:

A
D
E
K

They are absorbed from the intestinal tract with the fat portion of the diet. These four may be stored in the body, and like fats, are not excreted in the urine.

Water-soluble vitamins: In this group are:

thiamine (B_1);
riboflavin (B_2);
pantothenic acid;
niacin;
pyridoxine (B_6);
choline;
biotin;
folic acid;
B_{12} (cobalamin).

When the feed contains more water-soluble vitamins than the bird needs, excesses of all but one are excreted in the urine. Vitamin B_{12} has the

capability of being stored Those not stored must be included in the daily diet, the bird has no reservoir on which to draw

Vitamin A

True vitamin A exists only in the animal kingdom Its precursor, carotene, is found in the vegetable kingdom, and it too is fat soluble Carotenes are consumed through their vegetable sources to undergo conversion to provitamin A, then to Vitamin A, which can be stored in the body, mainly in the liver This vitamin is essential for normal vision, growth, egg production, and reproduction

Other name Antixerophthalmic vitamin

Unit of measurement Vitamin A activity is expressed as USP (U S Pharmacopeia) units or IU (International Units) They are equivalent Usually the activity of carotenes in plants is rated according to its vitamin A production in the body

Deficiency symptoms

(1) Retarded growth
(2) Weakness, ruffled feathers
(3) Absence of liquid from the tear glands Xerophthalmia and blindness may result There are cheesy exudates of the eyes in adult birds
(4) Egg production and hatchability are impaired
(5) The resistance of the bird to some poultry diseases is lowered

Sources of vitamin A Precursors of vitamin A are to be found in green leafy plants, alfalfa meal, yellow corn (maize), and corn gluten meal A good, dehydrated alfalfa meal (17% protein) should contain at least 100,000 USP units of vitamin A per lb (454 gm) Broiler rations are best prepared by using an alfalfa meal containing 20% protein and a minimum of 150,000 USP units of vitamin A Yellow corn contains about 2200 USP units per lb (454 gm), corn gluten meal, about 12,000 Vitamin A is found in many fish and animal liver meals It is produced commercially as a synthetic product of high and variable concentrations

Oxidation of vitamin A Carotenes and vitamin A are easily oxidized, reducing their potency in the feed ingredient in which they are present To reduce this oxidation, alfalfa meals are pelleted, antioxidants are sometimes added to certain feedstuffs, and synthetic vitamin A products are manufactured as small particles, then coated with fat, oil, or wax to produce stabilized forms In formulating feeds, care should be taken to use the actual present vitamin A activity of the ingredient rather than its original potency

Vitamin D

This vitamin has several forms, but D_2 and D_3 are the most important Vitamin D_3 (cholecalciferol) is utilized by birds, man, and 4 footed animals, while vitamin D_2 is of value to man and 4 footed animals Thus, vitamin D_3 becomes the essential form for poultry Vitamin D aids the absorption of calcium and phosphorus from the intestinal tract, thus increasing the amounts of these two minerals available for bone development, and the amount of calcium for eggshell deposition

Under natural conditions, the ultraviolet rays of sunshine act on 7-dehydro

cholesterol, synthesized in the bird, to produce cholecalciferol; which in turn is absorbed to become the only source of vitamin D the bird has. With the advent of commercial poultry production, chickens are closely confined to houses with no irradiation from the sun. Even glass does not allow the ultraviolet rays to pass. Vitamin D_3 supplements must be added to the feed, either from fish liver oils or from synthetic products.

Other names: Antirachitic vitamin; Sunshine vitamin

Unit of measurement: Vitamin D_3 is measured as ICU (International Chick Units).

Deficiency symptoms:

(1) Rickets: Calcium and phosphorus are not deposited in the bones in normal amounts. The hock joints are enlarged, the ribs are "beaded," and the beak and shanks in young chicks are soft and pliable.

(2) General unthriftiness

(3) Soft-shelled eggs

(4) Lowered egg production

(5) Reduced hatchability

Sources of vitamin D_3: Good natural sources of vitamin D_3 are the fish-liver oils. However, 7-dehydrocholesterol can be irradiated with ultraviolet light to produce cholecalciferol. This process is the basis for manufacturing commercial vitamin D products.

Vitamin E

Vitamin E (tocopherol) is a necessity for adequate productivity of the cells and for blood formation. When the diet is lacking in adequate amounts, there are several manifestations, but these vary because other dietary components affect the requirement for vitamin E. The tocopherol involved is alpha-tocopherol.

Other names: Antisterility vitamin; Alpha-tocopherol

Unit of measurement: The measure of alpha-tocopherol is in micrograms or milligrams (1 mg is equal to 1000 mcg).

Deficiency symptoms:

(1) Nutritional encephalomalacia, evidenced by a twisted neck, prostration, curled toes, and "crazy chick" disease.

(2) Exudative diathesis: There is some indication that selenium is involved, as additions of this mineral have been shown to reduce this difficulty when it results from a lack of adequate vitamin E.

(3) Male sterility: With prolonged deficiencies, the sterility may be permanent as a result of a degeneration of the testes.

(4) Nonproduction in the female: Birds stop laying on diets low in tocopherol, but cessation is not permanent, for additions of vitamin E to the diet restore the bird to normal egg production.

(5) Embryonic mortality: There is a circulatory failure at about the fourth day of egg incubation.

Sources of vitamin E: Whole grains and alfalfa meal are the best natural sources of vitamin E. Synthetic tocopherols are available, and these are usually added to chick starting and breeder rations.

Destruction of vitamin E: This vitamin is easily oxidized and the process

is increased when minerals and unsaturated fatty acids are present in the feed An antioxidant should be used in the ration when vitamin E is added

Vitamin K

This vitamin increases the clotting ability of the blood It is necessary for the synthesis of prothrombin, a chemical necessary for blood clotting When vitamin K is low or lacking, the blood vessels rupture, causing excessive hemorrhaging

There are several types of vitamin K, all of which are active but of varying potency, three of these are

(1) Vitamin K_1 (phylloquinone) Present in plant tissues

(2) Vitamin K_2 (menaquinone) Synthesized in small amounts in the intestinal tract

(3) Vitamin K_3 (menadione)

Other names Antihemorrhagic vitamin, Blood coagulation vitamin

Unit of measurement When supplementary vitamin K is added to the ration, it is usually in the form of menadione sodium bisulfate, and measured in milligrams

Deficiency symptoms

(1) Hemorrhagic syndrome Hemorrhages that are pinpoint in size at first and large later, occur on the flesh If the skin of the chicken is pulled off, bleeding may be seen on the breast, thighs, and ribs

Sources of vitamin K A good natural source of vitamin K is alfalfa meal Meat scrap and fish meal are fair sources

Thiamine

Thiamine is necessary to stimulate the appetite, to form certain enzymes necessary for digestion, and to prevent nervous disorders that culminate in polyneuritis However, as many feed ingredients carry abundant supplies of this vitamin, the symptoms are seldom seen

Other names Vitamin B_1, Antiberiberi vitamin, Antineuritic vitamin

Sources Thiamine is relatively abundant in cereal grains, mill by products, vegetable oil meals, and alfalfa meals

Riboflavin

This vitamin is of major importance, not only because of its effect on body processes, but because it generally is inadequate in rations composed of ordinary feedstuffs Riboflavin is a part of an enzyme probably needed by all living cells It may be isolated as yellow crystals Commercially it is manufactured by fermentation processes to produce the same form Most rations contain added riboflavin

Other names Vitamin B_2, Vitamin G

Unit of measurement The riboflavin unit of measurement usually is milligrams of the pure product

Deficiency symptoms

(1) Curled toe paralysis The toes curl and sometimes the legs are affected to produce paralysis

(2) Poor hatchability Embryos not hatching are dwarfed and have abnormal down termed "clubbed down"

Sources: Although fish meals, fish solubles, alfalfa meal, and milk products are relatively high in riboflavin, their limited use in most poultry feed formulas means that practically all poultry rations must include supplemental riboflavin.

Pantothenic Acid

This vitamin is associated with many protein molecules and is involved with protein, carbohydrate, and fat metabolism. It is relatively unstable. The requirements of young and growing chicks for pantothenic acid are high.

Other names: Vitamin B_5; chick antidermatitis factor.

Unit of measurement: The measuring unit is the milligram.

Deficiency symptoms:

(1) retarded growth in young chicks;
(2) ruffled feathers;
(3) granulated and stuck eyelids in young chicks;
(4) scabs at the corners of the mouth;
(5) dermatitis of the feet;
(6) lowered egg production;
(7) lowered hatchability.

Under field conditions, diets are seldom so low in pantothenic acid as to cause major exemplification of many of the symptoms.

Sources: Several feedstuffs are good sources of pantothenic acid, the list including liver meal, peanut meal, milk products, mill by-products, and alfalfa meal.

Calcium pantothenate is manufactured commercially to serve as the supplementary source of this vitamin. It is added to most rations.

Niacin

This vitamin is an important part of two enzymes. It is found as nicotinic acid in the plant kingdom and nicotinamide in the animal kingdom. The amino acid, tryptophan, is a precursor of niacin, and the ability of the bird to convert tryptophan must be considered when compounding poultry rations. As corn is a poor source of both, high-corn diets usually require a niacin supplement.

The chick requirement for niacin is relatively high, but it is low for laying birds. Growing embryos have a high requirement.

Other names: nicotinic acid; nicotinamide; pellagra-preventive factor.

Unit of measurement: Potencies are expressed in milligrams.

Deficiency symptoms:

(1) swollen hocks, similar to perosis, but the tendon seldom slips from the condyle;
(2) reduced growth;
(3) inflamed tongue and mouth (black tongue);
(4) scaly skin and feet and ruffled feathers;
(5) reduced feed consumption.

Pyridoxine

This vitamin is a growth stimulator in chicks and is abundant in most feedstuffs. It forms a part of several enzymes and is a muscle conditioner.

Other name Vitamin B_6

Unit of measurement Expressed as milligrams or micrograms

Deficiency symptoms Most practical diets do not produce symptoms, but laboratory diets low in pyridoxine show reduced growth of chicks

Choline

The demand of the chick for this vitamin is great Choline forms a part of the phospholipid, lecithin, rather than an enzyme Therefore, choline is seldom considered a true vitamin At times it may be synthesized by the chick, but the amounts derived from this source are usually inadequate The older a bird gets, the better the synthesis The vitamin has a great many functions in the body It helps in fat movement in the bloodstream, it has a sparing action on methionine, aids in growth, prevents a type of slipped tendon, and helps to reduce excessive fat deposits in the liver

Other name Choline chloride This chloride salt of choline is usually the feed additive The commercial product generally contains 25% choline chloride

Unit of measurement Milligrams or percent of the total formula

Deficiency symptoms

(1) perosis,
(2) fatty liver (syndrome),
(3) retarded growth

Sources Fish meal, fish solubles, yeast, liver meal, soybean oil meal, and distillers solubles are good sources

Biotin

Biotin seems adequate in the diet when the composition of normal feedstuffs is concerned, but only about half is available to the chicken Thus, it is possible that deficiencies may exist when some diets are fed At times biotin may be synthesized in the intestinal tract, but this process is highly variable

Unit of measurement The measure is the microgram

Deficiency symptoms

(1) scaly dermatitis,
(2) mild perosis,
(3) retarded growth,
(4) reduced hatchability

Sources Good feedstuff sources of biotin are liver meal and yeast

Folic Acid

Folic acid is a complicated chemical compound necessary for many physiological functions growth, muscle formation, blood formation, and feather growth Diets are seldom low in this vitamin

Other names Folacin, Pteroylglutamic acid

Deficiency symptoms

(1) depressed growth,
(2) poor feathering, with feathers lacking pigment,
(3) anemia,
(4) increased embryonic mortality

Sources Good sources are alfalfa meal, yeast, liver meal, and soybean oil meal

Vitamin B_{12}

This vitamin is associated almost entirely with feeds of animal and fish origin. It is synthesized by microorganisms of the intestinal tract as a cobalt-containing compound. However, the process is inadequate to supply the amount needed by most chickens. Lack of a normal amount causes anemia (pernicious anemia in man). Most rations contain a supplemental supply, particularly chick-starting and breeder diets. The bird's own droppings are a source of vitamin B_{12}. Therefore, birds raised on wire are more likely to show a deficiency than those kept on a littered floor.

Other names: Cobalamin; Animal protein factor

Deficiency symptoms:

(1) anemia;
(2) reduced chick growth;
(3) poor hatchability;
(4) fatty liver.

Sources: Meat scrap, fish meal, fish solubles, and poultry manure.

Asorbic Acid

In all probability this vitamin is not required by chickens.

Other names: Vitamin C; Antiscorbutic factor

UNIDENTIFIED GROWTH FACTORS

In spite of the knowledge of the basic feed ingredients, there are occasions when some natural feedstuff seems to improve the growth of chicks when added to purified diets containing all the known nutritive requirements in ample supply. At present there seem to be two unidentified factors in this group. Sources containing a good quantity of these factors are known even though the factors have not been identified. These two factors are:

(1) *Whey factor:* Sources are whey, distillers dried solubles, and yeast.
(2) *Fish factor:* Sources are fish meal, fish solubles, and fermentation products.

Distillers By-products

These are produced by drying the residue remaining after the fermentation of mash to produce alcohol. The product used to make the mash and the portions of the residue that are dried cause variations in the products. *Corn distillers dried solubles* is the predominant product. All such dried solubles are sources of the "whey factor" and the "fish factor."

MINERALS AND TRACE ELEMENTS

Besides proteins, carbohydrates, fats, and certain vitamins, many inorganic elements form a part of the bird's nutritional requirements. In most cases, the necessary quantity of each is small, often infinitesimal. Many have interrelationships with other nutrients. In some instances, trace amounts are necessary, but excesses are toxic. Although most of these elements must be added to the diet in their inorganic form, organic forms are important sources. High percentages of some are absorbed through the intestinal wall; in other instances, the amount is small.

Calcium

Calcium is primarily necessary for bone and eggshell formation but also has certain other functions The mineral is deposited in bone mainly as calcium phosphate, but there is some calcium carbonate Eggshells are almost entirely calcium carbonate

Eggshell formation At the approach of egg production (sexual maturity) estrogens are released from the ova in greater abundance, which in turn increase the level of blood calcium The parathyroid secretes hormones to keep the blood level of calcium constant Calcium is then deposited in the medullary bone to be released later for eggshell formation The amount deposited is not related to the amount of calcium fed during the growing period In fact, too much calcium during the growing period is a detriment to maximum egg production, probably because of injury to the developing parathyroid gland An increase in dietary calcium is needed only about one to two weeks before the first egg the pullet lays Self feeding of oystershell or other form of calcium during this period is the accepted field practice Once egg production begins, the source of calcium for eggshell formation is from both the dietary calcium and the medullary bone

There is some indication that not all the bird's requirement for calcium during egg production can be met by adding *pulverized* oystershell or limestone to the mash About two thirds of the supplementary calcium should be fed as flaked (large) oystershell, either self fed or mixed in the mash, and one third as pulverized *limestone* in the mash This procedure has been shown to improve eggshell quality The essence of this theory is that most of the shell is deposited by the hen during night time hours, and the need for calcium at this time is great Flaked oystershell and perhaps other forms of less soluble calcium supplements are slowly dissolved, most of the calcium reaching the bloodstream at night, when shell deposition occurs The bird would not have to draw entirely on her medullary bone supply for shell deposition at night, but could utilize the calcium from dietary sources

Feeding too much calcium to laying hens may be as detrimental as feeding too little As the amount of calcium in the diet is increased above 2% the percentage absorbed decreases and feed consumption is lowered Opposed to this is the fact that increases in dietary calcium tend to cause the production of eggs with better shells, but it also tends to depress egg production Certainly the free-choice feeding of calcium should not be a recommended practice To add to the complexities of feeding calcium, experimental work shows that increasing the calcium content of the diet to 6% during the last two weeks of cage egg production will increase the bone ash and the bone breaking strength

Phosphorus

Although a major constituent of the blood, phosphorus plays an important part in metabolic processes and is found in the cells, enzymes, and other body compounds Not all the phosphorus in the feed is available to the chicken Normally, the phosphorus content of the ration is represented by two measurements

(1) Total phosphorus
(2) Available phosphorus
Usually, chicks can utilize about 30% of the total plant phosphorus, while adult birds can utilize an average of 75%. Phosphorus derived from other than plant sources is available to the chicken in varying percentages based on solubility. The percents of available phosphorus in average rations are shown below:

Ration	Available Phosphorus as % of Total
Chick starting	60-65
Broiler	60-65
Grower	55-60
Layer	80-90

Calcium, Phosphorus, and Vitamin D

Not only are calcium and phosphorus essential dietary minerals for the production of bone, and calcium for the deposition of eggshell material, but vitamin D plays an important part in the process. Evidently vitamin D helps form a protein in the intestinal tract that helps to keep the calcium in solution so that it can pass the intestinal wall and reach the cells. Vitamin D also aids in other ways to get the calcium to those areas of the body which need it.

Amount of calcium and phosphorus in the diet: The dietary amounts of these two minerals must be maintained within close limits according to the age and type of bird involved. The following are typical examples:

Type of Ration	% Calcium	% Phosphorus	
		Total	Available
Starting	0.9	0.6	0.40
Growing	0.9	0.6	0.35
Laying	2.7-3.75	0.6	0.50

Calcium-phosphorus (Ca:P) dietary ratio: In many instances this is expressed as the ratio of calcium to *total* phosphorus in the ration, but a better meaning is given when it is the *dietary* ratio of calcium to *available* phosphorus. Examples of the latter are given below:

Type of Ration	Calcium : Available Phosphorus Ratio
Starting	2.2:1
Growing	2.5:1
Laying	6.5:1

Note: The figures given above for the amounts of calcium and phosphorus and the ratios are generalized. More precise figures are given in later chapters.

Sodium, Potassium, and Chlorine

These three elements are involved with acid base equilibria in the body Natural feedstuffs usually require supplemental feeding of salt (NaCl) to satisfy the bird's requirement for sodium and chlorine The amount of salt added to the ration should seldom be over 0 25 to 0 5% Too much salt produces a laxative effect Additions of over 8% are lethal

Potassium is a necessity, but ordinary poultry rations are seldom deficient in this element No supplementation is given

Sulfur

Sulfur is a part of two amino acids, cystine and methionine, which are often in short supply in natural feedstuff protein Sulfur is important to certain enzymes and hormones Inasmuch as normal poultry rations contain adequate sulfur, no supplements are necessary

Iodine

Iodine has a relationship to the thyroid and its hormone, thyroxine When the ration is low in iodine, the thyroid increases in size, producing a goiter Besides being a part of many metabolic functions in growing and adult birds, iodine is needed by the developing embryo When the iodine content of hatching eggs is low, hatchability is reduced

Iodine usually is added to the diet as potassium iodide in iodized salt See Chapter 25

Fluorine

Fluorine, a dietary necessity of the chicken, is associated with proper bone development Small amounts are required In many areas the requirement is supplied naturally by the fluorine in the water the chicken drinks, since many soils contain an abundance of fluorine which finds its way to the water supply But in other areas the water supply is almost devoid of fluorides In some localities fluorides are added to public drinking water (1 to 2 ppm) to aid in the formation of better teeth enamel in children But in large amounts, fluorides accumulate in the tissues and are toxic to the chicken Although fluorine is not added to poultry rations, it occurs in many minerals, such as limestones and phosphates Before being fed to chickens, these must be processed to lower their fluorine content The products are sold as *defluorinated rock phosphate* or *high-calcium limestones* Most of these have a fluorine content of less than 0 5% and can safely be fed to chickens

Iron and Copper

Nutritional anemia occurs when there are deficiencies of copper and iron The red blood cells contain iron The mineral also is needed to pigment the feathers of certain breeds of chickens Copper is necessary for iron utilization when hemoglobin is formed, therefore if absent from the diet, anemia results The amount of iron and copper needed in the diet of the chicken is quite specific, excesses may be toxic About 5 to 10 times as much iron as copper is required Usually, only small amounts if any, are ever added to the feed formula

Manganese

The chief function of manganese is to prevent perosis (slipped tendon), a condition where the hock joint becomes enlarged and the gastrocnemius tendon at this location slips from the condyle, twisting the shank to one side But manganese also is needed for normal growth, eggshell deposition, egg production, hatchability, and to prevent ataxia Since all rations composed of normal feedstuffs are deficient, manganese is added to the feed as manganese sulphate or manganous oxide A 70% feeding grade is commonly used From 30 to 50 gm of manganese are added to a ton (2000 lb) of feed

Magnesium

Magnesium is one of the essential trace elements of nutrition When it is absent from the diet, chicks grow slowly, exhibit convulsions, and may eventually die Deficiencies in laying rations produce a rapid drop in egg production Calcium is poorly utilized in the absence of magnesium An excess of magnesium in the diet is about as detrimental as too little One pronounced effect of an excess is wet droppings Some limestones (the dolomites) contain a high percentage of magnesium and are to be avoided

Selenium

This element is required in small amounts by the chicken Not only is it essential in itself, but it reduces some of the symptoms of vitamin E deficiency Exudative diathesis is one evidence of the lack of vitamin E, yet selenium has been shown to be capable of eliminating the condition It does not, however, affect encephalomalacia, another condition often present when vitamin E is lacking

The selenium content of plants is closely related to the amount of selenium in the soil on which the plants grow Where the soil is deficient, the plants and their seeds are deficient Excesses of selenium are toxic, reducing growth, hatchability, and increasing the incidence of embryonic malformations The optimum dietary level of selenium is 0 15 to 0 2 ppm

Caution In some countries it is illegal to add selenium to poultry feeds because of its residual effect in poultry meat and eggs Good *natural* sources of the mineral are fish meals, particularly those processed from tuna

Zinc

A small amount of zinc is needed by the chicken to foster good egg production, hatchability, proper feathering, and growth As feedstuffs generally are low in zinc, this mineral is usually added to the ration as zinc carbonate (about 57% zinc) or zinc oxide (about 80 5% zinc) Normally, from 15 to 30 gm of zinc are added to 1 ton (2000 lb) of feed

OTHER FEED CONSTITUENTS

There are other items added to feed in relatively small amounts Some are directly associated with metabolism, others are not

Antibiotics

Low levels of certain antibiotics are added to the formula to promote growth Their action is indirect, they alter the microbial environment of the intestines, thereby increasing the activity of certain other feed constituents

Arsenicals

Supplements of 3 nitro 4 hydroxyphenylarsonic acid, arsanilic acid, or sodium arsanilate are made to broiler diets to promote growth and to improve the yellow color of the skin and shanks Although the metal is deposited in the tissues, the amounts are very small, and once the arsenic source is withdrawn from the feed the tissues are depleted rapidly Any dietary source should be withdrawn from the feed at least five days before broilers are slaughtered Arsenicals in combination with certain other drugs should not be used in laying rations

Caution Be sure to check with authorities before using any arsenical

Xanthophylls

Xanthophylls compose a group of chemicals within a larger group of plant pigments known as *carotenoids* The xanthophylls impart yellow color to the fat deposits and skin of the birds and to egg yolk From this standpoint, the three most important xanthophylls are *lutein* *zeaxanthin*, and *cryptoxanthin* Xanthophylls are normally found in certain plants and seeds, and these furnish the dietary sources Lutein and zeaxanthin are the primary pigments of yellow corn and corn gluten meal, the main pigmenter in alfalfa meal is lutein

The xanthophylls differ in their density of yellow color, consequently they do not impart equal color to the skin of chickens nor to egg yolk However, the relationship between the content of the feed ingredient and the density of yellow pigment in the bird and eggs is quite close The quantity of xanthophylls in several feedstuffs is given below

Ingredient	Approximate Xanthophyll Content Mg/Lb	Mg/Kg
Marigold petal (meal)	3650	8030
Broccoli leaf (meal)	300	660
Red peppers (meal)	180	396
Dehydrated alfalfa meal	90-180	198-396
Corn gluten meal (41% protein)	70	154
Corn gluten meal (60% protein)	115	253
Yellow corn	10	22

Xanthophyll for broiler rations In order to pigment broilers properly, the ration should include from 6 to 12 5 mg of xanthophyll per lb (454 gm) An average broiler finisher ration contains 60% yellow corn, 1 to 2% alfalfa meal, and 4% corn gluten meal, and supplies approximately 10 mg of xanthophyll per lb (454 gm) of feed

Xanthophyll for layer rations Laying rations capable of producing eggs with a medium yellow yolk color should incorporate about 8 to 10 mg of xanthophyll per lb (454 gm) of feed When dark-colored yolks are required, as in the production of eggs for drying and freezing, the ration

will require from 20 to 30 mg of xanthophyll per pound. Usually it is necessary to add xanthophyll concentrates to produce such eggs.

Xanthophyll concentrates: Certain synthetic carotenoids are produced for feed use to supplement the xanthophylls of feedstuffs. These are widely used where natural sources are inadequate or darker skin or yolk pigmentation is required. From 2 to 10 gm of these are added per ton (2000 lb) of feed.

Antioxidant

Fat rancidity in a feed tends to destroy the fat-soluble vitamins, A, D, and E. Most of this oxidation of the fats may be prevented by adding antioxidants to the mixture. The two usually added at 0.0125% are:

(1) ethoxyquin
(2) butylated hydroxy toluene (BHT)

Coccidiostat

As an aid in suppressing coccidiosis-producing organisms, certain chemicals known as coccidiostats are added to most chick starting, broiler, and some growing rations. Levels of these coccidiostats should be those designated by the manufacturer. See Chapter 41, Coccidiosis.

Amino Acids

Of the 22 amino acids, 5 are deemed critical from a feed analysis standpoint, as the others usually are of normal supply from combinations of feedstuffs found in most poultry rations. The five are:

(1) methionine;
(2) cystine;
(3) lysine;
(4) tryptophan;
(5) arginine.

When a poultry ration is low in one or more of these five amino acids, certain protein supplements carrying large amounts or pure amino acids must be added to the feed formula to make up the deficiencies. Since methionine is most often lacking, most formulas call for supplementation in pure form as DL-methionine. One cause of methionine deficiency is the fact that large amounts of vegetable protein supplements are now used in feeds, plus low levels of the animal and fish proteins. Lysine and cystine often are inadequate when normal feedstuffs are used in poultry feeds.

Proper amino acid formulation requires minimum requirements of all, with little excess of any. This is practically impossible; there is some waste. Usually the value of the protein portion of the ration is determined by the limiting amino acid. Large amounts of others are usually of no value to the limiting one.

Some amino acid characteristics of the major feed ingredients are as follows:

barley:	low in tryptophan and lysine
corn:	low in lysine and arginine
sorghums:	low in lysine
soybean oil meal:	low in methionine; high in lysine
corn gluten meal:	low in lysine

fish meals	well balanced, but small amounts used
meat scrap	high in arginine and lysine
alfalfa meal	low in methionine, cystine, and tryptophan

Pellet Binders

Normally, the pellets processed from most mash mixtures tend to crumble To increase their hardness two products are commonly used

(1) powdered *bentonite*
(2) cellulose (from the wood pulp industry)

Tranquilizers

On many occasions, tranquilizers are added to poultry feeds to quiet birds being moved from place to place, to reduce the incidence of cannibalism, or to calm flocks affected with hysteria Although there are several tranquilizers, *reserpine* is used predominately Aspirin, ethylene glycol, and others are often used

Other Feed Additives

There are many other items added to feeds at times Dozens are used for the treatment or prevention of disease On occasion flavoring agents, enzymes, thyroactive compounds, and drugs to precipitate a molt are used

Feed Fundamentals

A study of poultry feeding should first include some of the measurements used to denote the daily nutrient requirement and to formulate rations. Feeding practices, feed forms, and ingredient interrelationships should also be discussed.

How Nutritive Requirements are Expressed

There is no precise manner in which the component parts of a ration or the nutritional requirements are expressed. Some of these variations are due to the fact that all countries and all scientists do not use the same units of measure. Milligrams per pound or milligrams per kilo are typical examples. Some of these variations are given below:

Major feed ingredients: Usually, these are expressed in percent.

Minor feed ingredients: Vitamin A is most often given as USP Units per pound or kilo. Vitamin D_3 is expressed as ICU or IU per pound or kilo. In the case of vitamin E, IU or milligrams per pound or kilo are used. Most other vitamins are expressed as milligrams, while trace minerals and amino acids are given in terms of percent.

Conversions:

ICU (International Chick Units): This is the measure of vitamin D_3 activity. Sometimes however, vitamin D_3 is measured in IU (International Units). For practical purposes the two are equal.

USPU (U.S. Pharmacopoeia Units): This is the unit for measuring vitamin A activity. Often IU (International Unit) is used. The two are equal. One USPU of vitamin A is equivalent to 0.6 mcg of carotene.

IU (International Units): *One measurement for vitamin E is the IU. It is* equivalent to 1 mg.

Gram conversions:

1,000 micrograms	=	1 milligram (mg)
10 milligrams	=	1 centigram (cg)
10 centigrams	=	1 decigram (dg)
10 decigrams	=	1 gram (gm)
1,000 milligrams	=	1 gram (gm)
1,000 grams	=	1 kilogram (kg)
1,000,000 milligrams	=	1 kilogram (kg)
1/1000 gram	=	1 milligram (mg)
28.349 grams	=	1 ounce (oz)
453.592 grams	=	1 pound (lb)
1 microgram per gram	=	1 part per million (ppm)
1 ppm	=	0.000001 percent

Calories

Small calorie (cal): A small calorie is the amount of heat required to raise the temperature of 1 gm of water 1°C. The small calorie is not often used in nutritional work.

Large Calorie (Cal) The amount of heat required to raise the temperature of 1000 gm of water 1°C Thus, 1 large calorie is equal to 1000 small calories The large Calorie is often spoken of as the kilocalorie (kcal) Often the energy value of a ration is given only as calories, meaning large calories It is conventionally capitalized when a large calorie is meant

Therm 1,000,000 small calories equal 1 therm

Expression of Requirements

Many feed elements are expressed in the formula as the quantity per pound, at other times, the amount per kilo Still others show the amount necessary per 100 lb or per short ton (2,000 lb) The metric ton (2,204 6 lb) is sometimes used When analyzing any feed requirements or feed formulas, care must be taken to determine which units are used

Energy

Energy is most often measured in heat units, the most common unit being the kilocalorie (kcal) There are two types of energy to be measured Productive Energy, and Metabolizable Energy

Productive energy (PE) Productive energy is the energy stored in the body as fat and protein, it varies according to the use of the bird PE is measured in Calories The term was generally used a few years ago to indicate the energy value of rations and feed ingredients, but it is not so popular today

Metabolizable energy (ME) Metabolizable energy is the energy available in feedstuffs minus the fecal and urinary energy The measure is the kilocalorie ME values are predominately used today to measure the energy values of a feed

Relationship between PE and ME There is no consistent relationship between the PE and ME values of feedstuffs except that the ME values are always higher The relationship varies according to the feedstuff itself Some examples are shown below

Feedstuff	PE as % of ME
Alfalfa meal (17% protein)	40
Whole barley	67
Yellow corn	72
Fish meal (65% protein)	70
Oats	69
Soybean oil meal (44% protein)	71
Meat and bone meal (50% protein)	83
Fat, animal	90
Fat, vegetable	75

Average relationship between ME and PE Although the individual feedstuffs vary in their ME-PE relationship, the PE in the *average poultry ration* is about 73% of the ME

Calcium:Phosphorus Ratio

Not only are the amounts of calcium and phosphorus in the ration of importance, but the relationship between the two has significance. The amounts of each in the feedstuff or feed in terms of percent are expressed as a ratio known as the *Ca:P ratio*.

Total phosphorus: When the *total* amount of phosphorus in the feedstuff is calculated, the ratio is expressed as the amount of calcium to *total* phosphorus.

Available phosphorus: When the amount of available phosphorus in the feedstuff is used, the ratio is given as the amount of calcium to *available* phosphorus.

Calorie/Protein Ratio (C/P ratio)

There is a close association between the number of calories of *PE* or *ME* in the ration and the percent of protein necessary to balance the energy. The ratio varies with the age of the birds and the use to which they are put. The ratio is expressed as a figure calculated by dividing the number of calories per pound of feedstuff by the percent of protein.

Example: The ration contains 1200 calories of ME per lb, and 20% protein. Thus, the C/P ratio is 60 (1200 ÷ 20 = 60).

Some recommended ratios on a pound basis according to the type of bird are given below:

Type of bird		(PE) C/P Ratio	(ME) C/P Ratio
Broilers	0-5 weeks	43	60
Broilers	6-10 "	53	72
Chicks	0-5 "	48	65
Growing	6-22 "	64	88
Laying & breeding	50% production	65	89
" "	60% "	60	82
" "	70% "	55	75
" "	80% "	50	68

FEEDING SYSTEMS

There are several methods of feeding a ration to chickens, but two have predominated through the years.

(1) *Mash-and-grain system:* Most of the poultry rations first formulated were used to supplement the locally produced cereal grains on the average small farm. At that time chickens were allowed to range, and they received some of their nutrients from insects and green grasses. Usually about one half the feed intake was from the grains, and one half from specially compounded mash mixtures. The percentage of the mash and grain could be varied when conditions made it necessary to raise or lower the percentage of protein in the entire diet. With the advent of commercial poultry production this system of feeding gave way to all-mash diets.

(2) *All mash system* As the knowledge of poultry feeding increased, it became possible to formulate rations that would include all the known nutrients They were *complete feeds* requiring no supplementation. This was a decided advantage, since under commercial poultry production, chickens were closely confined to houses or cages

Self-feeding

Within limits, the chicken has the ability to control its feed intake according to its needs. In the early days of poultry feeding the mash was self-fed, that is, it was kept before the birds at all times, and they could consume all they wished. Later, however, it was found that self-feeding was not an economical procedure, birds do tend to overeat, increasing the cost of their feeding program. Today, some rations are still self-fed, but many are given on a controlled basis, the amount of daily feed is allocated according to the weight and condition of the birds. This is an intricate procedure, but one that is essential for best results.

FORM OF FEED

Although the first poultry rations were in mash form, most are now available as crumbles or pellets as well

Mash Form

Many feed ingredients are in ground form, others, such as the whole grains, must be ground prior to mixing the ration The essence of a "mash" is that, in theory at least, each *bite* of feed is a balanced diet containing all the known nutrients in finely ground form. But birds find the finely ground mashes unpalatable, they are too dry and sticky. Therefore, mashes composed of materials of medium particle size improve the bird's ability to eat them readily. But it is impossible to secure all feed ingredients with this texture, some are available only as a finely ground product Therefore, it is of great importance that the cereal grains should not be ground to a fine consistency In turn, this means that chickens will have a tendency to pick out the larger cereal grain particles from the mash first, leaving the finer material until last. This constitutes a feeding problem, especially with many automatic feeders, as the birds nearest the feed hopper will tend to consume more of the more palatable grain portion of the feed mixture, leaving the finer materials for other birds in the pen or house.

Pellet Form

The mash may be compressed by running it through specialized equipment to form pellets of varying sizes These pelleting machines are composed of a die made up of dozens of holes of a specific diameter through which the feed is forced under pressure. Steam is often added to the feed just before pelleting to produce a firmer pellet At times, bentonite and other binders are added to the feed formula to increase the hardness of the pellet, up to 2% of sodium bentonite may be incorporated. When fat is added to the feed mix before pelleting, the pellets tend to crumble because the fat acts as a lubricant rather than as an adhesive To overcome this, pellets are first made and cooled, and hot fat sprayed on them

After complete pelleting there should be no fine material. Any such should be screened out and recycled.

Size of pellets· The size of a pellet is determined by its diameter and its length. A knife cuts the material extruded from the die in varying lengths. The size of the pellet is usually merchandized according to its diameter rather than its length. Small chicks require pellets with a small diameter. Larger birds are best fed those of a larger size.

Advantages and Disadvantages.—Pellets are used in abundance in many feeding programs, although they have some disadvantages. Care should be taken to study the effects of pellet feeding prior to entering into any program

Advantages of pellets

(1) They increase feed consumption.
(2) The pelleting process may improve the efficiency of the ration.
(3) There is less feed waste.
(4) Usually, pellets are easier to feed than mash.
(5) Certain fat-soluble vitamins are oxidized less rapidly.
(6) Pelleting destroys some bacteria and some viruses.

Disadvantages of pellets

(1) There is the added cost of pelleting the mash.
(2) Pellets may crumble, and the finer particles may be wasted.
(3) Pellets increase water consumption
(4) The droppings are wetter.
(5) Pellets increase the incidence and severity of cannibalism

Crumble Form

When pellets are coarsely ground, or preferably run through special cracking rolls, a type of product midway between mash and pellets results It has most of the advantages and disadvantages of pellets, but because of the smaller size, it may be fed to younger chicks. Often crumbles are used from one day of age

Coarseness of crumbles The texture of crumbles should be intermediate, neither too coarse nor too fine In fact, crumbles are best prepared by leaving some finer material in them. This enables younger chicks to eat more rapidly, and prevents some of the cannibalism which results from compressing all the feed particles. With many feed mixtures it is necessary to sift out some of the fine material from the crumbles and repellet it, to start the crumbling process over again so as to secure a coarser material.

Dietary Fiber and Pelleting

It has been found that the response to compressing a feed into pellets and crumbles is in part dependent on the fiber content of the original mash. Pelleting rations high in fiber (low in energy) show more response than pelleting feeds low in fiber (high in energy). Undoubtedly this is because high-fiber diets are less palatable to begin with, which results in lowered feed intake.

Effect of pelleting a low-energy ration· The effects of compressing a ration that is high in fiber (low energy) are shown by the following growth response:

Type of Feed	Average Weight at End of Test Grams
Mash	1,038
Crumbles	1,144
Pellets	1,203

In the above test, crumbles improved the growth by 10%, while pellets showed a 16% improvement. Although pelleting high-energy rations will produce little improvement in growth, there will be some, even when as much as 5% fat is added. Some feel that the pelleting process in itself improves the digestibility of some of the original feedstuffs.

Wet Mash vs. Dry Mash

A procedure of past years was to moisten the mash and feed it as a *wet mash*, supposedly to induce greater feed consumption. This may be true for the first day or two the wet mash is fed, but birds soon learn to adjust for the increased palatability, and feed consumption reverts to its normal level. Wet mash feeding will *not*

(1) increase egg production;
(2) increase egg weight,
(3) increase growth;
(4) increase feed conversion.

FEED ANALYSIS

Because there is seldom if ever a dietary deficiency of many of the nutritive components, nutritionists pay attention to only those components that are likely to be excessive, lacking, or deficient in the diet. This list usually includes the following:

metabolizable (or productive) energy	as kilocalories
protein (total)	as percent
amino acids	
lysine	as percent
methionine	as percent
methionine + cystine	as percent
fat	as percent
fiber	as percent
calcium	as percent
phosphorus	
total phosphorus	as percent
available phosphorus	as percent
vitamins	
vitamin A activity	as USPU
vitamin D_3	as ICU
riboflavin	as milligrams
pantothenic acid	as milligrams
choline	as milligrams
niacin	as milligrams

On occasion, some feed formulators will supplement the above list with the following:

linoleic acid	as percent
xanthophylls	as milligrams
amino acids	as percent of protein
C/P ratio	as a ratio
trace minerals (some)	as milligrams

FEED FORMULATION PRACTICES

Although feed formulas usually include all the necessary feedstuffs, there are many shortcuts in the actual manufacturing process. Therefore, the methods of compounding a ration require discussion.

Completed Feeds

Such rations are calculated to include all the feedstuffs necessary for the ration. The feed manufacturer sees that all the ingredients get into the feed mix, and the resulting products are sold as complete feeds. Although nothing more is to be added to the bird's diet, on occasion oystershell or some other source of calcium may be given as a supplement.

Concentrates

Many integrators and managers of country elevators have locally produced cereal grains available and need only the remainder of the feedstuffs to supplement these grains. Such items as the protein supplements, vitamins, minerals, and other feed components are mixed together and sold as concentrates. A calculated number of pounds of the concentrate is to be mixed locally with a certain number of pounds of cereal grain. Usually, there will be a separate concentrate for each type of feed being manufactured: chick starter, chick grower, layer, etc.

Vitamin and Mineral Premixes

Many feed manufacturers prefer to purchase their supply of vitamins, trace minerals, and other trace items in the form of premixes which contain these ingredients in the necessary amounts. A given number of pounds of such a premix is to be added to each ton of feed. Often there will be separate premixes for the different types of birds: broilers, chicks, layers, breeders, etc.

TABLE 29 1

PROTEIN AND AMINO ACID REQUIREMENT OF CHICKENS

Item	Broilers 0-6 Wk	Broilers 6-9 Wk	Replacement Pullets (Egg or Meat Type) 0-6 Wk	6-14 Wk	14-20 Wk
Protein (%)	23	20	20	16	12
Arginine (%)	1 4	1 2	1 2	0 95	0 72
Glycine (%)	1 15	1 0	1 0	0 8	0 6
Lysine (%)	1 25	1 1	1 1	0 9	0 66
Methionine (%)	0 86	0 75	0 75	0 6	0 45
or					
Methionine (%)	0 46	0 4	0 4	0 32	0 24
Cystine (%)	0 40	0 35	0 35	0 28	0 21
Tryptophan (%)	0 23	0 2	0 2	0 16	0 12

Source National Res Council, Nutrient Requirements of Poultry, Revised 1971

TABLE 29.2

MINERAL REQUIREMENTS OF YOUNG CHICKENS

Mineral	Starting Chickens (0-8 Wk) %	per Lb	per Kg	Growing Chickens (8-18 Wk) %	per Lb	per Kg
Calcium (%)	1 0			0 8		
Phosphorus (%)(1)	0 7			0 4		
Sodium (%)(2)	0 15			0 15		
Potassium (%)	0 2			0 16	?	?
Manganese (mg)		25	55		?	?
Magnesium (mg)		227	500		?	?
Iron (mg)		36	80		?	?
Copper (mg)		*1 8*	*4*		?	?
Zinc (mg)		*22 7*	*50*		?	?
Selenium (mg)		*05*	*0 1*			

Note Italicized figures are tentative
(1) At least 0 5% of the total feed of starting chickens should be inorganic phosphorus.
(2) Equivalent to 0 37% sodium chloride (salt)
Source National Res Council Nutrient Requirements of Poultry, Revised 1971

TABLE 29 3

VITAMIN REQUIREMENTS OF YOUNG CHICKENS

Vitamin	Starting Chickens (0-8 Wk) per Lb	per Kg	Growing Chickens (8-18 Wk) per Lb	per Kg
Vitamin A activity (IU)	*682*	*1500*	*682*	*1500*
Vitamin D (ICU)	91	200	91	200
Vitamin E (IU)	*4 6*	*10*	?	?
Vitamin K_1 (mg)	0 24	0 53	?	?
Thiamine (mg)	0 82	1 8	?	?
Riboflavin (mg)	1 6	3 6	0 82	1 8
Pantothenic acid (mg)	4 6	10	4 6	10
Niacin (mg)	12 3	27	5	11
Pyridoxine (mg)	1 4	3	?	?
Biotin (mg)	0 041	0 09	?	?
Choline (mg)	591	1300	?	?
Vitamin B_{12} (mg)	0 004	0 009	?	?

Note Italicized figures are tentative
Source National Res Council Nutrient Requirements of Poultry Revised 1971

Nutritive Requirements for Growth

The nutritive requirements of the chicken have been well established However, the interrelationship between many of the dietary components makes feed formulation quite complicated Only the more pertinent factors can be discussed in the next three chapters

ENERGY REQUIREMENTS FOR GROWTH

Starting and growing feeds are formulated to contain a prescribed amount of energy, usually measured in terms of kilocalories per pound or per kilo of ration Although the bird's *daily* need for energy would be a better criterion of its requirements, this is not practical because chickens are fed on a flock basis rather than individually Only because the chicken can partially govern its feed intake according to its need for energy is it possible to feed one ration to a group of birds of assorted sizes and development Theoretically, the smaller birds have a lower daily energy requirement and eat less feed, while larger birds with a greater need for energy consume more feed

Meeting Requirements Economically —Although rapid growth and high egg production are normally desired, economy of feeding enters the picture, and excellence in growth and egg production may become uneconomical Poultry rations are best formulated to produce the "*least cost*" pound of meat or dozen of eggs Following this procedure, it may at times be more profitable to induce slower growth and to accept the production of fewer eggs in order to reduce the feed cost per unit of production As margins of profit have shrunk with the advent of commercial poultry raising, the necessity for *feed cost management* has increased, and economical feeding has become more important than ever Many changes have taken place in feed formulation and feed administration to meet these requirements

Sources of Energy —The chicken derives its energy from the carbohydrates, fats, and protein in its food When the energy sources are properly balanced with protein, minerals, and vitamins, maximum productive efficiency results As the chicken has a mechanism to control its energy intake according to its daily requirement, the needs of the bird according to its age and purpose must be known The environment under which the bird is raised also is a factor Once the daily energy requirement is known, it is possible to formulate a ration that is adequate and balanced

Metabolizable Energy vs Productive Energy —The amount of energy available to the bird through the feed source is best measured in terms of metabolizable energy (ME) See Chapter 28 This energy represents that actually used by the bird, including maintenance Metabolizable energy is a better indicator than productive energy (PE) The ME values are more consistent and are easily reproduced in various laboratories

ME Requirement for Young and Growing Birds —Chick starting diets used during the first 5 or 6 weeks and diets fed during the growing period between 6 weeks and 20 weeks should contain about 1318 kilocalories of ME per lb (2900 kcal/kg) of ration The figure applies to rations used for both laying and meat type strains

TABLE 29 1

PROTEIN AND AMINO ACID REQUIREMENT OF CHICKENS

Item	Broilers		Replacement Pullets (Egg or Meat Type)		
	0-6 Wk	6-9 Wk	0-6 Wk	6-14 Wk	14-20 Wk
Protein (%)	23	20	20	16	12
Arginine (%)	1 4	1 2	1 2	0 95	0 72
Glycine (%)	1 15	1 0	1 0	0 8	0 6
Lysine (%)	1 25	1 1	1 1	0 9	0 66
Methionine (%)	0 86	0 75	0 75	0 6	0 45
or					
Methionine (%)	0 46	0 4	0 4	0 32	0 24
Cystine (%)	0 40	0 35	0 35	0 28	0 21
Tryptophan (%)	0 23	0 2	0 2	0 16	0 12

Source National Res Council Nutrient Requirements of Poultry, Revised 1971

TABLE 29 2

MINERAL REQUIREMENTS OF YOUNG CHICKENS

Mineral	Starting Chickens (0-8 Wk)			Growing Chickens (8-18 Wk)		
	%	per Lb	per Kg	%	per Lb	per Kg
Calcium (%)	1 0			0 8		
Phosphorus (%)(1)	0 7			0 4		
Sodium (%)(2)	0 15			0 15		
Potassium (%)	0 2			0 16		
Manganese (mg)		25	55		?	?
Magnesium (mg)		227	500		?	?
Iron (mg)		36	80		?	?
Copper (mg)		*1 8*	*4*		?	?
Zinc (mg)		*22 7*	*50*		?	?
Selenium (mg)		*05*	*0 1*			

Note Italicized figures are tentative

(1) At least 0 5% of the total feed of starting chickens should be inorganic phosphorus.

(2) Equivalent to 0 37% sodium chloride (salt)

Source National Res Council Nutrient Requirements of Poultry Revised 1971

TABLE 29.3

VITAMIN REQUIREMENTS OF YOUNG CHICKENS

Vitamin	Starting Chickens (0-8 Wk)		Growing Chickens (8-18 Wk)	
	per Lb	per Kg	per Lb	per Kg
Vitamin A activity (IU)	*682*	*1500*	*682*	*1500*
Vitamin D (ICU)	91	200	91	200
Vitamin E (IU)	*4 6*	*10*	?	?
Vitamin K_1 (mg)	0 24	0 53	?	?
Thiamine (mg)	0 82	1 8	?	?
Riboflavin (mg)	1 6	3 6	0 82	1 8
Pantothenic acid (mg)	4 6	10	4 6	10
Niacin (mg)	12 3	27	5	11
Pyridoxine (mg)	1 4	3	?	?
Biotin (mg)	0 041	0 09	?	?
Choline (mg)	591	1300	?	?
Vitamin B_{12} (mg)	0 004	0 009	?	?

Note Italicized figures are tentative

Source National Res. Council Nutrient Requirements of Poultry, Revised 1971

ME Requirement for Broilers—About 1455 kilocalories of ME per lb (3200 kcal/kg) of ration are necessary in broiler starting and finishing formulas, although the ME is often increased about 100 kcal per lb (220 kcal/kg) in *finishing rations* This increases the amount of fat in the tissues, producing a more delicious broiler Most broiler rations include some added fat in order to attain the high energy values

Protein Requirements

The protein requirement of the growing chick is based on its need for amino acids in correct proportions Therefore, *quality protein* is a requisite of proper feed formulation as well as the correct percentage of protein in the diet As most poultry rations are modifications of a corn soybean meal base *certain amino acids are likely to be deficient, methionine being the one most often affected* Any vitamin deficiencies in natural feedstuffs can be overcome by adding other protein supplements or synthetic amino acids to the ration

An analysis of a feed mixture or feed formulation must include the amounts of certain essential amino acids as well as the total protein These requirements are given in Table 29 1

Protein Energy Relationship —There must be a proper ratio between the energy and the protein in the diet It is a fallacy to set the protein percentage without first knowing the energy content of the ration After these relationships are determined, a check of the formula to ascertain the adequacy of the essential amino acids must be made

Examples of the energy protein (ME/P) ratios from Table 29 1 are as follows

Bird and Age	Kcal ME per Lb	Kcal ME per Kg	% Protein	ME/P Ratio (Lb)
Broilers				
0–6 wk	1455	3200	23	63
6–9 wk	1455	3200	20	73
Replacement egg type pullets				
0–6 wk	1318	2900	20	66
6–14 wk	1318	2900	16	82
14–20 wk	1318	2900	12	110

When adjustments are made in the energy content of a ration, the protein percentage must be adjusted accordingly, to maintain the correct ME/P ratio

Mineral Requirements

The mineral requirements of young growing chicks are given in Table 29 2 The list contains the major items, plus trace items often found inadequate in natural feedstuffs

Vitamin Requirements

The vitamin requirements for growth are given in Table 29 3 These figures include *no* margin of safety, and feed formulators will often prescribe much larger amounts than those listed, particularly for vitamins that are subject to oxidation

Nutritive Requirements for Egg Production

Feeding the laying bird is only a continuation of feeding the growing pullet *plus* supplying the necessary ingredients in the correct proportions so that the bird may produce an abundant number of eggs. The nutritive demand for egg production in modern strains of chickens is tremendous. The eggs produced by a pullet during a laying year weigh eight times as much as she weighs and she will increase her body size by 25%. To do this, she will have to eat nearly 20 times her body weight in feed.

The essence of good nutrition during the laying period is to provide the nutrients for maintenance, growth, and egg production while preventing the bird from gaining too much weight. Since the dry matter of eggs is composed mostly of fat and protein, the energy and protein portions of the laying diet are important. The fact that hens do not lay at a constant rate throughout their egg production period also influences the dietary requirement. When production is low, as at the end of the laying year, the nutritional requirement will be different from that during the height of egg production.

REQUIREMENTS FOR EGG PRODUCTION

Energy Requirements

White Leghorns and medium-size layers producing brown-shelled eggs require a diet with about 1300 kcal of ME per lb (2860 kcal/kg) of feed. Often, however, the Calories are reduced during the latter part of the egg production period to provide for "phase feeding." See Chapter 35 and Table 30.2. Layers on the floor should receive a diet slightly higher in ME than those kept on wire floors (cages).

The daily energy requirement of the laying bird is highly variable. Some reasons for this are:

(1) variation in body weight of pullets;
(2) environmental temperature;
(3) amount of bird activity;
(4) variations in egg production;
(5) differences in egg size;
(6) prevalence of stress;
(7) age of the bird;
(8) amount of feather cover.

The only compensating fact in overcoming the above variations is that each bird is able to govern her feed intake according to her energy needs. But whether the governing mechanism is efficient is a question. Good feeding requires changes in the feed formula or in the method of feeding to help the bird regulate her energy intake. These are discussed in Chapter 35.

Protein Requirements

The protein requirement of laying birds is closely associated with the rate of egg production. Protein in the egg production diet is much lower than the 18 to 23% required for early growth. Just prior to egg production, only 13% of the pullet's

diet should be protein, but when egg production reaches its peak, the requirement may be as high as 18 or 19% At the end of the production cycle, it may drop to as low as 15%

Amino Acids—The laying bird's requirements of the amino acids are given in Table 30 1

TABLE 30 1

AMINO ACID REQUIREMENTS OF LAYERS

Amino Acid	*Amount in the Diet*
Arginine (%)	0 8
Glycine (%)	?
Lysine (%)	0 5
Methionine (%)	0 53
or	
Methionine (%)	0 28
Cystine (%)	0 25
Tryptophan (%)	0 11

Source National Res Council Nutrient Requirements of Poultry Revised 1971

When one diet is used throughout the laying year it should contain approximately 1300 kcal of ME per lb (2860 kcal/kg) of feed and about 16% protein This would provide a ME/P ratio of 81 (pound basis) Because this type of feeding program is not as economical as altering the protein percentage in the ration as egg production changes, it has given way to phase feeding The environmental temperature also necessitates variations in the energy and protein content of the ration More practical formula recommendations are given in Table 30 2

TABLE 30 2

ENERGY AND PROTEIN VARIATIONS IN LAYING RATIONS

% Egg Production (Hen day)	Hot weather				Cool weather			
	M E per Lb	M E per Kg	% Protein	M E /P (Lb) Ratio	M E per Lb	M E per Kg	% Protein	M E /P (Lb) Ratio
80 and over	1250	2750	18	69	1400	3080	17	82
70–80	1225	2695	17	72	1375	3025	16	86
under 70	1200	2640	16	75	1350	2970	15	90

Note Rations used during moderate weather should be between the extremes shown above Many commercial feed manufacturers make changes in their laying feed formulas as the weather changes

Mineral Requirements

Because of the high requirement of calcium for eggshell production, this mineral is most important in the feeding of laying hens Not only does the need for calcium vary with the rate of egg production, but also with environmental temperature Furthermore, excesses of calcium in the diet reduce the utilization of other minerals and make the feed unpalatable Recent experimental evidence shows that eggshell quality is improved if a part of the dietary calcium is supplied by

flaked oystershell or other form of less soluble calcium carbonate Those forms that are slowly dissolved in the alimentary tract release their calcium into the bloodstream at night, when the actual eggshell is being deposited

Although the National Research Council gives the calcium requirement for laying diets as 2 75%, this is certainly a bare minimum Most feed formulators provide about 3 00% during cool weather and 3 50% during hot weather More is needed at the end of the laying year than at the start Rations for heavy hens (medium size, egg type) require less calcium than those for Leghorns, as the heavy bird eats more feed but lays no more eggs See Table 30 3

TABLE 30 3

MINERAL REQUIREMENTS OF LAYING HENS
(Moderate Weather)

	Leghorn		Medium size (Brown shelled Eggs)	
Mineral	20–40 Wk of Age	40 and over Wk of Age	20–40 Wk of Age	40 and over Wk of Age
Calcium (%)	3 25	3 50	3 00	3 25
Phosphorus (%)	0 6	0 6	0 6	0 6
Sodium (%)	0.15	0 15	0 15	0 15

Trace Minerals —The requirement of the laying bird for trace minerals is very indefinite Except for manganese, natural feedstuffs seem to supply the necessary quantities Most layer rations include supplementary manganese

Vitamin Requirements

The dietary vitamin requirements of a laying ration are given in Table 30 4 In some cases the figures are not known, probably because the need is low or the

TABLE 30 4

VITAMIN REQUIREMENTS OF LAYING HENS

Vitamin	Amount per Unit of Feed per Lb	Amount per Unit of Feed per Kg
Vitamin A activity (IU)	1818	4000
Vitamin D (ICU)	227	500
Vitamin E (IU)	?	?
Vitamin K_1 (mg)	?	?
Thiamine (mg)	?	?
Riboflavin (mg)	1 0	2.2
Pantothenic acid (mg)	1 0	2.2
Niacin (mg)	*4 6*(*)	*10*(*)
Pyridoxine (mg)	1 4	3
Biotin (mg)	?	?
Choline (mg)	?	?
Vitamin B_{12} (mg)	?	?

Note Italicized figures are tentative
(*) In diet that contains 0 15% tryptophan
Source National Res Council Nutrient Requirements of Poultry Revised 1971

particular vitamin is adequately supplied in natural feedstuffs The vitamins usually added to a laying ration include

vitamin A	pantothenic acid
vitamin D_3	choline
vitamin B_{12}	niacin
riboflavin	

Nutritive Requirements for Hatching Egg Production

High hatchability and production of quality chicks require additions of certain proteins, vitamins, and minerals to the common laying ration to produce a ration suitable for breeding hens. Therefore, except for a few changes, breeder rations are basically laying rations.

In reality there are two types of breeding rations:

(1) *Those for egg-type lines:* These consist of rations for Leghorn and medium-size breeder lines laying brown-shelled eggs. As these lines differ in size, but lay a similar number of eggs, the feed for each line requires an adjustment in the formula or the feeding method to compensate for the size variations.

(2) *Those for meat-type lines:* These are broiler breeder parents. They are kept only for the production of hatching eggs; there are no "laying rations" involved. These lines are nearly twice as heavy as Leghorn strains, and lay fewer eggs. Meat-type lines of chickens require not only special rations, but special methods of feed administration. See Chapter 36.

REQUIREMENTS OF BREEDERS

Energy Requirements

The energy requirement of the breeder diet for egg-type strains is identical with diets for egg production alone. However, the diets may contain varying caloric levels. Birds may be fed low-, medium-, or high-energy rations. In such instances the bird adjusts her feed intake to provide a uniform daily supply of energy. The hens will eat less of a high-energy ration than a low-energy ration. Again, however, it may be necessary to control the feed intake of diets high in energy to prevent the breeder from getting too heavy.

Meat-type strains are not only larger than egg-type breeders, but being bred for fast growth in the broiler house they tend to get too heavy during the growing and laying periods if the ration is self-fed. The higher the energy level in the feed, the greater the difficulty. Besides, meat-type breeders produce fewer eggs, particularly after they have been laying for several weeks. For these reasons the energy content of meat-type breeder rations usually is lower than that of egg-type breeder formulas.

Protein Requirements

As with other types of rations, the percentage of protein in the breeder ration must be governed in part by the energy content.

An average protein content for a breeder formula would be 15 to 16%, but is subject to great variation according to the environmental temperature, caloric content of the diet, rate of egg production, size of birds, etc.

Mineral Requirements

As with the bird's need for large amounts of calcium for egg production, there is a similar requirement in its need for calcium for the production of quality

TABLE 31 1

MINERAL REQUIREMENTS OF BREEDERS
(Moderate Weather)

Mineral	Leghorn (Wk of Age) (20–40)	(over 40)	Medium-size (Wk of Age) (20–40)	(over 40)	Meat type (Wk of Age) (20–40)	(over 40)
Calcium (%)	3 25	3 50	3 00	3 25	2 75	3 00
Phosphorus (%)	0 6	0 6	0 6	0 6	0 6	0 6
Sodium (%)	0 15	0 15	0 15	0 15	0 15	0 15

hatching eggs The calcium, phosphorus, and sodium requirements are given in Table 31 1

Vitamin Requirements

Table 31 2 gives the vitamin requirements for hatching egg production Usually these are about the same as for commercial egg production except that additional amounts of riboflavin and pantothenic acid must be added to obtain good hatchability

TABLE 31 2

VITAMIN REQUIREMENTS OF BREEDING HENS

Vitamin	Amount per Unit of Feed per Lb	per Kg
Vitamin A activity (IU)	1818	4000
Vitamin D (ICU)	227	500
Vitamin E (IU)	?	?
Vitamin K_1 (mg)	?	?
Thiamine (mg)	0 36	0 8
Riboflavin (mg)	1 73	*3 8*
Pantothenic acid (mg)	4 6	10
Niacin (mg)	*4 6*(*)	*10*(*)
Pyridoxine (mg)	2 1	4 5
Biotin (mg)	*0 07*	*0 15*
Choline (mg)	?	?
Vitamin B_{12} (mg)	*0 0014*	*0 003*

Note Italicized figures are tentative
(*) In diet that contains 0 15% tryptophan
Source National Res Council, Nutrient Requirements of Poultry Revised 1971

FEED REQUIREMENTS OF BREEDING MALES

The nutritional requirements of breeding males center around maintenance and body growth Theoretically, a ration for males should contain less of those feed components necessary for egg production and hatchability in the breeding hen diet However, males must be kept in the same pen as the females and it is impos sible to provide separate diets for the cockerels and pullets Therefore, the males must get the same ration as the females, even though it is obvious that the males are not getting full utilization of the feed they eat

Analysis of Feedstuffs

In order to formulate poultry rations it is necessary to have tables showing the analysis of the various feedstuffs. These values are necessary to build formulas that are properly balanced for the type and age of bird involved, and for the environment under which it is kept. However, the ability to calculate a proper diet is the result of long experience and training in the field of poultry nutrition. There are many combinations of feedstuffs that would provide calculated requirements for growth and reproduction, yet would not be good diets. Many of the feedstuffs would have deleterious effects when given at percentages greater than the optimum—they would be unpalatable, toxic, or otherwise impractical.

But once the specified amounts of a feedstuff are included in a formula, the analysis tables do provide a basis for determining whether the minimum nutritive requirements for protein, fats, minerals, vitamins, etc., have been met.

An analysis of the more common feedstuffs used in poultry nutrition work is given in Tables 32.1 and 32.2. Most tables of this type are subject to some variability, since researchers use different methods for arriving at the figures.

TABLE 32.1

POULTRY FEED INGREDIENT ANALYSES

Ingredient	M E (Kcal/Lb)	Percent					Vit A (IU/Lb)	Xanthophyll Mg/Lb
		Protein	Fat	Fiber	Ca	P		
Alfalfa meal (20%)	640	20.0	2.6	17.0	1.90	0.22	150000	150
Alfalfa meal (17%)	500	17.0	2.5	26.0	1.10	0.21	100000	120
Barley, ground	1190	11.0	2.1	6.0	0.07	0.36	—	—
Bone meal, steamed	450	6.5	0.6	2.6	31.30	14.50	—	—
Corn dry steepwater concentrate	1170	31.0	3.0	—	—	—	—	—
Corn, yellow, ground	1530	8.9	4.0	2.0	0.02	0.27	2270	10
Corn DDG with solubles	1050	28.0	8.0	7.0	0.19	0.35	1100	8
Corn distillers dried solubles	1250	27.0	5.0	2.0	0.35	1.55	—	—
Corn ferm solubles, dried extract	980	23.4	0.25	0.2	0.07	1.55	—	—
Corn gluten feed (yellow)	650	21.0	1.0	10.0	0.30	0.70	1000	30
Corn gluten meal (11%)	1180	41.0	2.0	3.0	0.07	0.37	12000	60
Corn gluten meal (60%)	1580	60.0	2.7	2.0	0.18	0.39	20600	160
Dicalcium phosphate	—	—	—	—	23.00	18.50	—	—
Fat								
Animal tallow, feed grade	3130	—	97.0	—	—	—	—	—
Fish oil	3190	—	95.0	—	—	—	—	—
Hydrolyzed *animal* & vegetable fat	3100	—	99.0	—	—	—	—	—
Poultry oil	3720	—	98.0	—	—	—	—	—
Yellow grease	3100	—	99.0	—	—	—	—	—
Fish meal								
Canadian herring 72%	1450	72.0	9.0	0.5	2.10	2.20	—	—
Maine herring, 65% *(10% fat)*	1420	65.0	10.0	0.5	3.00	2.30	—	—
Atlantic menhaden + 40% solubles	1330	62.0	9.0	0.5	5.50	3.00	—	—
Atlantic menhaden (58–65% protein)	1210	60.0	9.0	1.0	6.20	3.60	—	—
Peruvian	1200	65.0	4.0	1.0	3.80	2.50	—	—
Fish solubles, condensed	575	31.5	4.6	0.5	0.15	0.63	—	—
Grain sorghums, Milo	1500	10.5	3.0	2.5	0.01	0.32	—	—
Hominy feed (yellow)	1370	10.6	5.8	5.1	0.08	0.52	1600	—
Hydrolyzed poultry feathers	1160	87.0	5.0	1.1	0.22	0.77	—	—
Limestone, ground high calcium	—	—	—	—	38.00	—	—	—
Limestone, ground, low magnesium	—	—	—	—	35.00	—	—	—
Meat and bone meal (50% protein)	900	50.0	10.0	2.5	10.00	5.00	—	—
Meat and bone meal (17% protein)	870	17.0	11.0	2.0	12.00	6.00	—	—
Molasses, cane	890	3.0	—	—	0.65	0.08	—	—

Oats, ground	1170	11.0	4.5	11.0	0.10	0.36	—	—
Oyster shells, ground	—	—	—	—	38.00	—	—	—
Peanut meal	1200	44.0	6.1	11.8	0.17	0.56	—	—
Poultry by-product meal	1260	55.0	12.0	2.5	3.00	1.35	—	—
Sesame meal	820	42.0	7.0	6.5	2.00	1.30	—	—
Soybean meal (dehulled)	1120	49.0	0.5	2.5	0.20	0.60	—	—
Soybean meal (44% protein)	1020	44.0	0.5	5.2	0.30	0.60	—	—
Wheat, ground	1410	12.0	1.9	2.4	0.04	0.39	—	—
Wheat, bran	510	15.6	4.2	9.0	0.11	1.21	—	—
Wheat, middlings	890	16.0	4.5	7.5	0.08	0.93	—	—
Whey, dried	860	12.5	0.7	0.3	0.85	0.70	—	—
Yeast, dried	880	45.0	3.0	1.4	1.30	1.25	—	—

Source: New England College Conf. Board.

TABLE 32 2

POULTRY FEED INGREDIENT ANALYSES (Continued)

Ingredient	Mg per Pound				Percent				
	Riboflavin	Pantothenic Acid	Choline	Niacin	Arginine	Lysine	Methionine	Cystine	Tryptophan
Alfalfa meal (20%)	8 40	17 00	500	24 00	1 10	0 98	0 34	0 38	0 27
Alfalfa meal (17%)	6 70	16 00	400	22.00	0 76	0 86	0 30	0 33	0 25
Barley, ground	0 59	3 00	500	31 10	0 54	0 34	0 19	0 22	0 11
Bone meal, steamed	—	—	—	—	1 70	0 90	0 20	0 10	0 05
Corn dry steepwater concentrate	—	—	—	—	—	—	—	—	—
Corn, yellow, ground	0 73	2 09	227	9 08	0 44	0 21	0 19	0 16	0 08
Corn DDG with solubles	3 45	5 30	1800	37 00	1 10	0 65	0 44	0 38	0 22
Corn distillers dried solubles	7 00	11 00	2500	68 00	0 94	0 84	0 50	0 37	0 18
Corn ferm solubles, dried ext	2 40	6 65	484	109 50	1 00	1 00	0 54	0 49	0 10
Corn gluten feed (yellow)	1 20	4 00	500	30 00	0 80	0 80	0 30	0 50	0 20
Corn gluten meal (41%)	1 00	6 00	750	13 60	1 34	0 74	0 98	0 61	0 22
Corn gluten meal (60%)	0 80	5 40	215	28 85	2 20	1 40	1 60	0 90	0 30
Dicalcium phosphate	—	—	—	—	—	—	—	—	—
Fat									
Animal tallow, feed grade	—	—	—	—	—	—	—	—	—
Fish oil	—	—	—	—	—	—	—	—	—
Hydrolyzed animal & veg fat	—	—	—	—	—	—	—	—	—
Poultry oil	—	—	—	—	—	—	—	—	—
Yellow grease	—	—	—	—	—	—	—	—	—
Fish meal									
Canadian herring 72%	4 50	8 00	2200	35 00	5 30	6 50	2 10	1 00	0 90
Maine herring 65% (10% fat)	4 00	4 00	1800	40 00	4 80	5 70	1 90	0 80	0 80
Atlantic menhaden + 40% solubles	2 10	3 50	1300	20 00	3 97	5 50	1 80	0 79	0 73
Atlantic menhaden (58–65% prot)	3 10	4 00	1230	38 59	3 97	5 50	1 80	0 79	0 73
Peruvian	1 00	4 50	1600	40 00	3 60	5 30	1 70	0 75	0 70
Fish solubles, condensed	7 70	17 25	1250	117 50	1 55	1 65	0 56	0 21	0 16
Grain sorghums, Milo	0 50	3 90	200	33 00	0 36	0 23	0 16	0 17	0 10
Hominy feed (yellow)	1 06	3 98	501	20 68	0 50	0 25	0 15	0 13	0 12
Hydrolyzed poultry feathers	0 90	4 25	400	11 00	5 75	1 75	0 56	2 65	0 57
Limestone, ground, high calcium	—	—	—	—	—	—	—	—	—
Limestone, ground, low magnesium	—	—	—	—	—	—	—	—	—
Meat and bone meal (50% protein)	2 10	1 50	990	21 40	3 15	2 60	0 58	0 57	0 31
Meat and bone meal (47% protein)	2 10	1 50	990	21 40	2 77	2 30	0 50	0 50	0 27

Molasses, cane	1.23	15.58	366	14.40	—	—	—	—	—
Oats, ground	0.59	4.65	420	6.60	0.70	0.40	0.20	0.21	0.14
Oyster shells, ground	—	—	—	—	—	—	—	—	—
Peanut meal	2.40	25.05	795	76.20	4.40	1.33	0.47	0.71	0.44
Poultry by-product meal	4.50	4.00	2720	18.00	3.75	3.70	0.99	0.98	0.45
Sesame meal	1.50	2.50	680	6.00	4.80	1.30	1.40	0.57	0.78
Soybean meal (dehulled)	1.20	6.50	1150	13.50	3.53	3.14	0.69	0.72	0.63
Soybean meal (44% protein)	1.49	6.22	1050	9.08	3.16	2.82	0.63	0.66	0.57
Wheat, ground	0.55	5.00	330	27.50	0.53	0.38	0.20	0.22	0.16
Wheat, bran	1.35	11.40	460	139.00	0.93	0.56	0.21	0.21	0.22
Wheat middlings	1.15	7.20	500	56.50	0.86	0.59	0.21	0.19	0.20
Whey, dried	10.90	21.00	700	8.50	0.38	0.97	0.28	0.34	0.21
Yeast, dried	16.00	50.00	1500	200.00	2.10	3.23	0.78	0.48	0.56

Source: New England College Conf. Board.

Poultry Rations

There are definite *basic* components of a poultry feed Within each component several different feedstuffs may be used to satisfy the nutritive requirements For example, the carbohydrate portion of the diet might be made up of one of the following

corn,
corn and milo,
corn and oats,
milo and barley,
etc

Basic Components of a Ration

(1) *Carbohydrates* This includes the cereal grains and other high carbohydrate ingredients Carbohydrate sources make up the largest segment of the ration
(2) *Fats* Supplementary fats are often added to build high-energy diets
(3) *Mill by products* By products from the milling of wheat, rice, and corn are included in this list
(4) *Green leafy material* Dried alfalfa products or those produced from green grasses and other plants
(5) *Vegetable protein* Meals produced from soybeans, cottonseed, pea nuts, etc , fall in this group to make it the second largest portion of the formula
(6) *Fish and animal protein* This group includes fish meals, meat scrap, etc Although grouped together, fish and animal sources must be considered separately
(7) *Amino acid supplements* A great many mixtures of natural feedstuffs are deficient in one or more amino acids, and supplementation must be made
(8) *Major minerals* These are sources of calcium and phosphorus
(9) *Trace minerals* Manganese, iron, copper, zinc, etc , are included in this list
(10) *Antibiotic supplement* Certain rations, such as those used for broiler feeding, include a small amount of an antibiotic as a growth stimu lator Such antibiotics are not to be confused with those used for medicinal purposes
(11) *UGF factor* When maximum growth is needed, the ration should con tain a source or sources of the UGF factor
(12) *Vitamins* These are supplementary vitamin concentrates
(13) *Antioxidants* To prevent rancidity and destruction of certain feed components by oxidation, antioxidants are added to many feed mixtures
(14) *Medicaments and drugs* Coccidiostats and other drugs are incorpo rated in many feed formulas

(15) *Other:* These include supplementary sources of xanthophylls, hormones, enzymes, pellet binders, flavors, and several other items. They are used only under certain conditions.

The above list gives the major feed segments under which practically all feedstuffs may be classified. There are about 40 dietary nutrients in a ration, and most poultry feeds should contain 20 to 25 ingredients to supply the minimum nutritional needs of the chicken.

Basis for Formulation

The units of measure used in feed formulation have been given in Chapter 28. The requirement of each nutritional item is usually computed as a number of units per pound or per kilo or percent of the feed mixture. To be more practical, however, rations are computed on the basis of the number of units or percent per ton (2000 lb) of feed, this being the amount in a "batch" of feed when produced in a feed manufacturing plant.

Nutrient Requirement Based on Feed Energy

The energy content of the ration will govern the chicken's daily feed consumption. The amount of each of the other nutrients in the ration must be related to the feed's caloric content. This recommendation is based on the premise that the bird has a daily requirement of each nutritional factor; when there is a variation in feed consumption as a result of dietary changes in the caloric value of the ration or environmental or other factors, causing the bird to eat more or less feed, an adjustment must be made in the nonenergy portion of the diet. To follow this rule explicitly would entail the devotion of countless hours to formula changes. Normally, such changes in the ration are made only when there is a *major* need for alteration.

Dietary Requirements per 1000 Kilocalories of ME

Some nutritional scientists compute the makeup of a ration on the basis of 1000 kilocalories of metabolizable energy, because these figures should remain relatively constant regardless of the caloric value of the formula. But this is not entirely true, and the system is subject to controversy. As an example of an error arising when this procedure is used, it is known that the daily calcium requirement of the laying bird is largely determined by the rate of egg production rather than by her caloric intake. Regardless of the ME values of the ration, the daily calcium needs of the bird are practically constant, to provide for the deposition of eggshell material.

High-energy Rations More Efficient

Normally, high-energy rations are more efficient and more economical than low-energy feeds. But the terms involving energy levels are not definite; a high-energy diet for broilers would have a higher ME value than a high-energy ration for young, replacement egg-type strains of chicks. Table 33.1 shows an average relationship.

Note: The figures in Table 33.1 are average, but there are many factors in the chicken house that determine the caloric values of a poultry ration. Temperature, phase feeding, body weight, stress, etc., have a definite bearing. Many birds are kept on a program of controlling their feed intake

TABLE 33 1

CALORIC RELATIONSHIP BETWEEN HIGH MEDIUM , AND LOW ENERGY RATIONS

Type of Ration	Approximate Kilocalories of ME per Unit of Ration					
	High energy		Medium energy		Low energy	
	per Kg	per Lb	per Kg	per Lb	per Kg	per Lb
Chick starting	2970	1350	2860	1300	2750	1250
Broiler starting	3190	1450	3135	1425	3080	1400
Broiler finishing	3410	1550	3300	1500	3190	1450
Growing	2970	1350	2805	1275	2695	1225
Egg type laying	2970	1350	2904	1320	2838	1290
Meat type laying	2904	1320	2772	1260	2640	1200

so that their body weight can be more carefully regulated This program necessitates changes in the feed formula

Phase Feeding

The use of phase feeding during egg production, whereby the protein percentage is lowered during the last one half to two thirds of the laying year, has an eco nomic significance Such rations usually call for a reduction of about 3% in their protein content

Concentrates

Many poultrymen either have their own feed mills or have access to commercial mills Such poultrymen may wish to use some locally available cereal grains or soybean oil meal, but do not wish to get involved with the processing of the in gredients necessary for the entire formula The alternative in this case is to pur chase a concentrate composed of all ingredients not secured locally Many types of these concentrates are available, and they are usually formulated so that the final mixture is identical with the basic ration

Premixes

To facilitate mixing of trace ingredients such as minerals, vitamins, etc , the feed manufacturer will prepare at least mineral and vitamin premixes A filler is added to give the mixture more volume to aid in better dispersion of the trace ingredients throughout the final feed mix There must be a balanced premix for each type of ration manufactured, e.g , starting, growing, breeding, etc Many such premixes are commercially available Vitamins and minerals should not be placed in a single premix, use two separate ones for each type of feed mix

EXAMPLES OF FEED FORMULAS

It is impossible to present the hundreds of possibilities for feed formulas Only one example of each type is given each is rather basic and represents a starting point for formulating similar rations with other ingredients

Starting, Growing, and Breeding Rations

Table 33.2 lists four rations along with their calculated analysis:

(1) *Chick Starting:* To be used for egg and meat-type laying strains from one day of age through the fifth week (35 days).

(2) *Chick Growing:* This is a pullet-growing ration to be used from the beginning of the sixth week (36 days) until egg production starts.

(3) *Breeding:* Two rations are given:

(a) For 3½ to 5-lb (1.6 to 2.3-kg) egg-type lines, including Leghorn and medium-size layers producing brown-shelled eggs.

TABLE 33 2

STARTING, GROWING, AND BREEDING RATIONS*

Ingredient		Starter	Grower**	Breeder 3½-5 Lb	Breeder 5-8 Lb
Ground yellow corn (2,3)*		1,247	1,338	1,281	1,333
Wheat middlings		100	300	—	100
DDGS or equivalent (1)***		50	—	50	50
Alfalfa meal (17%) (100,000 A/lb)		50	50	50	50
Soybean meal (dehulled)		398	206	301	185
Fish meal, herring (65%) (4,5)		50	—	50	75
Meat and bone meal (47%) (5)		49	50	50	50
Dicalcium phosphate (6)		10	10	7	2
Ground limestone, low magnesium (7)		19	19	141	128
dl Methionine		—	—	0 5	—
Yellow grease (16)		20	20	63	20
Iodized salt		7	7	7	7
Antibiotic supplement		(8)	—	—	—
Antioxidant		(9)	(9)	(9)	(9)
Coccidiostat		(10)	(10)	—	—
Zinc (grams) (17)		—	—	16	16
Manganese (grams) (11)		52	52	52	52
Vitamin supplements (12)					
Vitamin A	(USP units)	1,000,000	1,000,000	4,000,000	4,000,000
Vitamin D_3	(ICU)	1,000,000	1,000,000	2,000,000	2,000,000
Vitamin E	(IU)	—	—	2,000	2,000
Vitamin B_{12}	(mg)	6	6	6	6
Riboflavin	(mg)	1,500	1,500	3,000	3,000
Calcium pantothenate	(mg)	3,000	3,000	6,000	6,000
Choline chloride	(mg)	160,000	41,000	114,000	140,000
Niacin	(mg)	10,000	10,000	20,000	20,000
Totals (lb) (21)		2,000	2,000	2,000 5	2,000
Calculated Analysis (25)					
Metabolizable energy	Cal/lb	1,350	1,340	1,350	1,315
Protein	%	20 00	15 00	17 00	16 00
Lysine	%	1 02	0 63	0 85	0 77
Methionine	%	0 34	0 25	0 33	0 30
Methionine + cystine	%	0 65	0 48	0 59	0 55
Fat	%	4 59	4 73	6 52	4 84
Fiber	%	3 00	3 42	2 54	2.83
Calcium	%	0 91	0 83	3 00	2.75
Total phosphorus	%	0 65	0 63	0 55	0 55
Available phosphorus (13)	%	0 40	0 35	0 48	0 47
Vitamins (units or mg/lb)					
Vitamin A activity	USP units/lb	4,410	4,520	5,950	6,010
Vitamin D	ICU/lb	500	500	1,000	1,000
Riboflavin	mg	1 91	1 75	2 55	2.61
Pantothenic acid	mg	5 12	5 08	5 99	6 07
Choline	mg	600	400	500	500
Niacin	mg	19 17	22 02	20.85	23 61

*( ) See footnotes.
** See footnote 14
*** Corn distillers dried grains with solubles.
Source: New England College Conf Board.

(b) For 5 to 8-lb (2.3 to 3.6-kg) meat-type lines to be used for birds producing hatching eggs.

Egg-type Laying Rations

Rations for laying birds are given in Table 33.3. They may be categorized as follows:

(1) *Rations for hens kept in cages*
  (a) Leghorns, 3½ to 5 lb (1.6 to 2.3 kg)
  (b) Medium-size, 5 to 7 lb (2.3 to 3.2 kg)

(2) *Rations for hens kept on a littered floor*
  (a) Leghorns, 3½ to 5 lb (1.6 to 2.3 kg)
  (b) Medium-size, 5 to 7 lb (2.3 to 3.2 kg)

TABLE 33.3

EGG TYPE LAYING RATIONS*

Ingredient		Caged Birds		Floor Birds	
		3½-5 Lb	5-7 Lb	3½-5 Lb	5-7 Lb
Ground yellow corn (2,3)*		1,293	1,314	1,344	1,311
Wheat middlings		—	100	—	137
DDGS or equivalent (1)**		50	50	—	—
Alfalfa meal (17%) (100,000 A/lb)		25	25	25	25
Soybean meal (dehulled)		308	244	340	314
Fish meal, herring (65%) (4,5)		50	40	40	—
Meat and bone meal (47%) (5)		50	50	50	50
Dicalcium phosphate (6)		15	8	5	—
Ground limestone, low magnesium (7)		148	142	144	136
dl Methionine		0 5	0 4	0 6	0 6
Yellow grease (16)		53	20	45	20
Iodized salt		8	7	7	7
Antioxidant		(9)	(9)	(9)	(9)
Zinc (grams) (17)		16	16	—	—
Manganese (grams) (11)		52	52	52	52
Vitamin supplements (12)					
Vitamin A	(USP units)	6,500,000	6,500,000	5,000,000	5,000,000
Vitamin D_3	(ICU)	2,000,000	2,000,000	2,000,000	2,000,000
Vitamin B_{12}	(mg)	6	6	4	4
Riboflavin	(mg)	2,000	2,000	2,000	1,000
Calcium pantothenate	(mg)	4,000	4,000	2,500	2,000
Choline chloride	(mg)	313,000	150,000	173,000	213,000
Niacin	(mg)	20 000	20 000	20,000	20,000
Totals (lb) (21)		2,000 5	2,000 4	2,000 6	2,000 6
Calculated Analysis (25)					
Metabolizable energy	Cal/lb	1,340	1,302	1,350	1,300
Protein	%	17 00	16 01	17 00	16 00
Lysine	%	0 85	0 75	0 86	0 74
Methionine	%	0 33	0 31	0 33	0 29
Methionine + cystine	%	0 59	0 55	0 59	0 54
Fat	%	6 04	4 61	5 50	4 30
Fiber	%	2 24	2 55	2 15	2 59
Calcium	%	3 20	3 00	3 00	2 75
Total phosphorus	%	0 62	0 58	0 52	0 49
Available phosphorus (13)	%	0 55	0 50	0 45	0 40
Vitamins (units or mg/lb)					
Vitamin A activity	USP units/lb	5,970	5,990	5,270	5,240
Vitamin D	ICU/lb	1,000	1,000	1,000	1,000
Riboflavin	mg	1 98	1 99	1 91	1 38
Pantothenic acid	mg	4 82	4 97	4 08	4 12
Choline chloride	mg	600	500	500	500
Niacin	mg	20 68	22 98	20 00	22 74

*( ) See footnotes.
** Corn distillers dried grains with solubles
Source New England College Conf Board.

No endeavor is made to provide formulas for other types of laying rations. These would include high- and low-energy rations, those used for phase feeding, those for environmental temperature changes, and high-calcium diets. Many of these are detailed in Chapter 35.

Broiler Rations

Two typical broiler rations are given in Table 33.4:

(1) *Broiler Starter.* This ration is to be used until the broiler chicks are five weeks (35 days) of age

(2) *Broiler Finisher* The Finisher should be fed beginning with the sixth week (36 days).

Footnotes for Tables 33.2, 33.3, and 33.4

Formulas given in the above mentioned tables are necessarily abbreviated and in many instances there is a choice of ingredients or other substitutions These are itemized as follows

(1) Wherever substitutions are made in the rations, the total nutrient content should be adjusted to meet established requirements

(2) From 200 to 400 lb of coarsely ground wheat or yellow hominy may be used to replace an equal amount of corn If wheat is used, add 200,000 IU of vitamin A for each 100 lb of corn removed

(3) There is usually some loss of provitamin A activity in corn and alfalfa during storage. If stored ingredients are used, it may be advisable to increase the added vitamin A level of the ration by 1,000 or 2,000 IU per lb. This can be accomplished by increasing the recommended supplement by 2,000,000 or 4,000,000 IU per ton (2,000 lb) of feed.

(4) If a high salt fish meal is used, *omit* from the added salt an amount equal to that supplied by the fish meal

(5) Poultry by-product meal may be substituted for all the meat and bone scrap and up to 50% of the fish meal Correct for calcium and phosphorus loss due to the substitution of poultry by-product meal.

(6) Based on an 18 5% phosphorus product Steamed bone meal or defluorinated rock phosphate may replace the dicalcium phosphate on a phosphorus basis.

(7) Based on 35% calcium limestone.

(8) An antibiotic may be used in these rations at the level recommended by the manufacturer.

(9) 1,2-dihydro-6-ethoxy-2,2,4-trimethylquinoline (ethoxyquin) or butylated hydroxytoluene (BHT) are antioxidants used in the chick starter and broiler ration, and ethoxyquin in the breeder ration, at the 0 0125% level to help prevent destruction of the fat-soluble vitamins If desired, either may also be added at the 0 0125% level (0.25 lb per ton).

(10) A coccidiostat or antihistomonal may be used in these rations as required, at levels recommended by the manufacturer.

(11) This amount of manganese will be furnished by 0.5 lb of manganese sulfate or 0.21 lb of manganous oxide (70% feeding grade). An equivalent amount of manganese may be added from other acceptable sources

TABLE 33 4

BROILER RATIONS*

Ingredient		Starter (18)	Finisher (18)
Ground yellow corn (3)*		1,130	1,250
Alfalfa meal (20%) (200,000 A/lb)		—	25
Soybean meal (dehulled)		561	390
Corn gluten meal (60%)		50	80
Fish meal, herring (65%) (4,5)		115	100
Dicalcium phosphate (6)		18	19
Ground limestone, low magnesium (7)		23	20
Yellow grease		95	109
Iodized salt		8	7
Antibiotic supplement		(8)	(8)
Antioxidant		(9)	(9)
Coccidiostat		(10)	(10)
Zinc (grams) (24)		30	30
Manganese (grams) (15)		75	75
Organic arsenical supplement (19)		0 1	0 1
Vitamin supplements (12)			
Vitamin A	(USP units)	4,000,000	4,000,000
Vitamin D_3	(ICU)	1,000,000	1,000,000
Vitamin K (20)	(mg)	1,000	1,000
Vitamin B_{12}	(mg)	12	12
Riboflavin	(mg)	3,000	3,000
Calcium pantothenate	(mg)	5,000	5,000
Choline chloride	(mg)	480,000	660,000
Niacin	(mg)	20 000	20,000
Totals (lb) (21)		2,000 1	2,000 1
Calculated Analysis (25)			
Metabolizable energy	Cal/lb	1,460	1,500
Protein	%	24 00	21 00
Lysine	%	1 36	1 10
Methionine	%	0 45	0 42
Methionine + cystine	%	0 81	0 74
Fat	%	7 75	8 61
Fiber	%	1 91	2 05
Calcium	%	0 85	0 80
Total phosphorus	%	0 63	0 59
Available phosphorus (13)	%	0 40	0 38
Vitamins (units or mg/lb)			
Vitamin A activity	USP units/lb	3,800	6,120
Vitamin D	ICU/lb	500	500
Riboflavin	mg	2 50	2 53
Pantothenic acid	mg	5 87	5 70
Choline	mg	800	800
Niacin	mg	21 93	21 75
Xanthophyll	mg	9 66	14 52

*( ) See footnotes.
Source New England College Conf Board

(12) Caution should be used when high potency vitamin mixes are involved It is recommended that 10 lb be the minimum amount of any item added to a ton of feed to insure proper mixing Thus, high potency vitamin, mineral, or drug mixes should be premixed with a carrier (such as corn meal) to such a dilution that 10 lb of the final mix will be added for each ton of feed mixed Minerals and vitamins should not be premixed together

(13) Available phosphorus has been taken as 30% of total phosphorus from plant sources for chicks, and 75% of total phosphorus from plant sources for adult birds. Phosphorus from other than plant sources is considered to be 100% utilized.
(14) For those wanting a restricted feeding program, feed the grower 80% or less of the amount normally consumed.
(15) This amount of manganese will be furnished by 0.7 lb of manganese sulfate or 0.3 lb of manganous oxide (70% feeding grade). An equivalent amount of manganese may be added from other acceptable sources.
(16) Where maintaining body weight in layers is a problem, increase the fat by 1 or 2% during winter months by replacing an equal amount of cereal grains to provide a higher energy level.
(17) Approximately this amount of zinc will be furnished by 29 gm of zinc carbonate or 20 gm of zinc oxide. An equivalent amount of zinc may be used from other acceptable sources.
(18) To be fed as all-mash rations. Feed the starting ration until the birds are 35 days old.
(19) Based on 3-nitro-4-hydroxyphenylarsonic acid at a level of 45 gm (0.1 lb) per ton (2,000 lb). Other compounds that may be used at a level recommended by the manufacturer are sodium arsenilate or arsenilic acid.
(20) Based on menadione. Other compounds supplying equivalent levels of vitamin K may be used.
(21) If an even 2,000 lb is desired, adjust by removing or adding ground yellow corn.
(22) May be fed with grain after 20 weeks.
(23) This amount of manganese will be furnished by approximately 0.3 lb of manganese sulfate or 0.13 lb of manganous oxide (70% feeding grade). An equivalent amount of manganese may be added from other acceptable sources.
(24) This amount of zinc will be furnished by approximately 53 gm of zinc carbonate or 37 gm of zinc oxide. An equivalent amount of zinc may be added from other acceptable sources.
(25) Any discrepancies in calculated analysis that occur in the decimal part of the figures are due to rounding errors built in by the computer used in the calculations.

Very important: The Food and Drug Administration of the U.S. Department of Health, Education and Welfare and other governmental bodies around the world have published a series of regulations concerning the addition of additivies, such as arsenicals, antibiotics, coccidiostats, hormones, and other drugs, to animal feeds. For information concerning the use of any additive, consult the supplier of the additive in question.

Feeding Egg-Type Growing Pullets

This chapter deals with egg type pullets, the feeding of meat type birds is covered in Chapter 36 The period involved is from the time the chicks are one day of age until they reach sexual maturity, which is approximately 21 weeks of age

Growing and developing a good pullet is one of the most important items in the operation of a poultry farm Undoubtedly, the quality of the bird at the time her production cycle begins will greatly determine how profitable she will be during her period of lay Therefore, special emphasis must be placed on feeding the growing bird so that she may develop into a healthy, productive individual Mistakes made during the growing phase cannot be corrected during the laying cycle

What does feed management involve? There must be not only well balanced growing rations, but also a program of feed allocation that will produce a pullet with optimum weight and maturity at the lowest possible cost How best to feed the ration is as important as correct feed formulation However, proper feed management rests with the judgment of the poultry producer His ability to make changes in his feeding procedure according to fluctuations in temperature, body weight of the bird, maturity, and a vast assortment of other variable conditions will determine how well he can grow a pullet

Factors Affecting Pullet Development

There are several factors of importance in pullet development But the major rule that applies is in two parts, and each part is extremely important Each group of egg type pullets must reach sexual maturity (first egg)

(1) at the correct weight for that particular strain,

(2) at an age that is optimum to produce eggs economically during her laying year

From a feeding standpoint, the following have a bearing on this rule

(1) *Genetics* The size (weight) of a strain of layers at sexual maturity is a derivation of genetics Although there is little evidence that the basic feed formula need be altered according to the strain involved, feed management during the growing period is important so that the birds may reach their desired weight when they lay their first eggs

(2) *Season of hatch* Two problems that confront the poultryman when chicks are started at different months of the year, with only normal daylight and full feeding, are as follows, and are shown in Table 34 1

(a) Those pullets raised during decreasing light days reached sexual maturity at an older age

(b) The younger the bird at sexual maturity, the smaller her egg size

These normal variations in flock behavior must be corrected in order to secure profitable laying house performance

(3) *Light stimulation* Table 34 1 clearly indicates the importance of having a light-control program during the growing period Feed control

TABLE 34.1

EFFECT OF DATE OF HATCH ON AGE AT SEXUAL MATURITY AND EGG SIZE

Month Hatched	Days to 25% Egg Production	% Large Eggs (12 Months Production)	% Eggs under 22 Oz per Doz
January	164	87.1	10.5
February	172	86.5	10.6
March	184	89.0	7.9
April	187	93.1	4.8
May	189	94.1	3.9
June	195	93.8	3.7
July	190	86.4	8.9
August	202	93.6	4.1
September	200	93.4	4.1
October	179	80.2	14.3
November	150	78.5	16.6
December	147	72.3	22.6

Source: Skoglund, Univ. of Delaware.

(restriction) also will delay the onset of egg production, but its effects are most pronounced only with flocks maturing in open-sided houses during days of decreasing light-day length.

(4) *Stress:* Chickens are subjected to stresses during the growing stage; many of these are man-made. Most stresses cause a reduction in the daily feed consumption, and some method of increasing the nutritional intake becomes the responsibility of the poultry caretaker.

(5) *Management practices:* Many management practices call for a change in the feed formula and feeding method. Whether birds are to be raised on a littered floor or in cages with wire floors is a typical example. As birds exercise less in cages than on the floor, their daily energy requirement is lower.

(6) *Nutritional imbalance:* To delay the onset of egg production, a vast array of imbalanced feeding programs has been suggested. Rations high in iodine, low in lysine, low in protein, all-corn, etc., have been used. Some can be self-fed; others must be subjected to controlled feeding.

(7) *Feed management:* When full-fed, each strain of layers has an inherent ability to grow at a certain rate and to reach sexual maturity with a certain body size. But the inherent size may not be optimum. Only by careful feed control during the growing period will the best mature weight be attained. Although the bird has some control over her caloric intake to meet her demands, this mechanism is far from perfect. She cannot compensate for all the environmental variations, stresses, etc., with which she comes in contact.

Full feeding vs. restricted feeding: For a bird to grow according to her bred-in ability, there must be some method of controlling the caloric intake. There are three major methods:

(a) controlling the feed intake;

(b) increasing or decreasing the amount of fiber in the diet, thereby altering the caloric intake,

(c) regulating the amount of time that the birds have access to feed each day (so-called "Limited Time Feeding," which seems less practical for growing birds than for laying pullets)

FEEDING THE FIRST FIVE WEEKS

During the first five weeks of the life of the chick, a well balanced chick *starter* should be self fed In some instances, the starter is fed for 7 or 8 weeks, but any period longer than 5 weeks usually is uneconomical However, when the *grower* ration has a low protein percentage, it may be advisable to feed the starter for a period longer than five weeks

Composition of the Starter Formula

The starter is a complete feed, and under most conditions should contain the following

Protein (%)	20
Fat (%)	4-5
Metabolizable energy (kcal/lb)	1318
Metabolizable energy (kcal/kg)	*2900*
Fiber (%)	3–4
Calcium (%)	0 9
Phosphorus (%)	0 6

Medicaments The most common medicament for a chick starter is a coccidiostat It must be added at a rate that will completely suppress multiplication of the parasite The only alternative is to use a program of coccidiosis vaccination See Chapter 41 On occasion, other chemicals to prevent the incidence of disease or stress are added to the starter diet on a regular basis

Form of Feed

Mash or crumbles may be used for starter rations Crumbles should not be too coarse, the larger the size the more difficult it is for chicks to eat them the first few days Any mash form of feed should be of medium coarseness When the tex ture is too fine, the feed becomes difficult to eat and chicks do not relish it as well

Growth During First Five Weeks

When based on the percentage increase over the weight of the previous week, the most rapid gains are made when the chick is young As the chick grows older, the weekly increments of weight become materially less, as shown in Table 34.2

Feed Consumption and Feed Conversion

Feed consumption during the first 5 to 8 weeks will vary according to the strain of birds, the energy content of the ration, room temperature, and a vast number of other conditions Guidelines for averages involving all variables are shown in Table 34 3 Figures are for chicks on a self feeding program Increases in weekly feed consumption and feed conversion are obvious

TABLE 34.2

INCREASES IN WEEKLY WEIGHT THROUGH EIGHT WEEKS

Age		Percent Increase in Weight Over Previous Week	
Wk	Days	Leghorn Pullets	Medium-size Pullets*
1	7	90	95
2	14	60	68
3	21	41	48
4	28	33	32
5	35	20	26
6	42	20	20
7	49	19	19
8	56	19	18

*Producing brown-shelled eggs.

Feeding Problems

If the starter ration is adequate and the feed is self-fed, no nutritional difficulties should be encountered with a healthy flock the first few weeks. But normal feed consumption is important. Many management factors influence the feed intake. Water consumption during this period is important. Stresses should be avoided. Provide adequate floor space and correct brooding temperatures. See Chapter 13.

FEEDING FROM FIVE TO TWENTY WEEKS

This is a critical period in the development of an egg-type pullet, for how well she is grown will have an important bearing on her productivity during her laying period. A pullet must develop at a rate appropriate for her strain and reach sexual maturity at an opportune and economical age.

The nutritional requirements during the growing phase are vastly different from those during the starting period. However, the primary difference involves the

TABLE 34.3

FEED CONSUMPTION AND FEED CONVERSION DURING STARTING PERIOD

Week	Leghorn			Medium-size*		
	Feed Consumption for Week		Feed Conversion for Week	Feed Consumption for Week		Feed Conversion for Week
	Lb	Kg		Lb	Kg	
1	0.20	0.09	—	0.25	0.11	—
2	0.28	0.13	2.33	0.39	0.18	2.30
3	0.38	0.17	2.90	0.43	0.20	2.80
4	0.47	0.21	3.13	0.61	0.28	3.05
5	0.56	0.25	3.70	0.64	0.29	3.10
6	0.59	0.27	3.93	0.67	0.30	3.19
7**	0.60	0.28	3.53	0.70	0.32	2.91
8**	0.63	0.29	3.15	0.74	0.34	2.70

* Laying brown-shelled eggs.
** Mild feed restriction.

amount of protein in the growing ration Compared with the starting ration, protein must be reduced materially, not only to justify the bird's requirement, but to produce a pullet at the lowest cost possible

Dietary Energy for Growing Pullets

The amount of energy in the starting and growing rations should be the same—about 1318 kcal of M E per lb (2900 kcal/kg) of ration However, this type of growing diet will not prove optimum under all conditions A problem often arises during hot weather because the birds will not eat enough feed, body weights are low During cold weather they eat too much, birds gain weight too rapidly

Dietary Protein for Growing Pullets

The amount of protein in the ration for the growing pullet should be reduced as her body weight increases This is necessarily brought about because the *daily* protein requirement of the growing bird is relatively constant But because she is eating more feed each day, her daily protein intake would increase if the percentage in the ration were not reduced Any protein that was consumed above her daily requirement would do the bird no good, and would certainly add to the cost of maturing the pullet

The growing bird's requirement for protein is better indicated by her body weight than by her age, as shown later Normally, the *total protein* in the ration should be reduced by about 1% per week after the fifth week until it is 13% This point is reached when the birds are about 14 weeks of age However, weekly adjustments are impractical Usually changes are made but twice during the growing period (1st period) 6 to 14 weeks, and (2nd period) 14 to 20 weeks On occasion the growing period may be divided into three phases But regardless of the breakdown, there also are additional necessary formula adjustments due to environmental temperatures and other factors

Phase Feeding to Egg type Pullets

Although the minimum protein percentages in the growing ration have been established by the National Research Council as 16% between five and 14 weeks, and 12% thereafter, these figures are somewhat low under field conditions where birds are subjected to stresses of varying kinds Most producers of pullets prefer not to drop below 13% protein in the diet during the last growing phase At the present time the most practical diets under commercial conditions appear to be those outlined in Table 34 4

Requirements of a Single Growing Ration

Where one growing ration is used from 5 weeks to 21 weeks of age, it should contain

M E (kcal/lb)	1318
M E (kcal/kg)	2900
Protein (%)	15
M E /P ratio (lb)	88

Energy and Protein as They Affect Growth

To show the variations encountered when the dietary energy and protein are altered and full fed to growing Leghorn pullets, an experiment is presented in

TABLE 34.4

PHASE FEEDING RATION REQUIREMENTS DURING GROWING
(For egg-type pullets)

Item	Two-phase System		Three-phase System		
	5-14 Wk	14-20 Wk	5-12 Wk	12-16 Wk	16-20 Wk
M.E. (kcal/lb)	1318	1318	1318	1318	1318
M.E. (kcal/kg)	*2900*	*2900*	*2900*	*2900*	*2900*
Protein (%)	17	13	17	15	13
M.E./P ratio (lb)	78	101	78	88	101
Kcal M.E. per gram of protein	17	22	17	19	22

Table 34.5. It is obvious from a study of this table that:
(1) increasing the protein in the diet increased the body weight at maturity, and also decreased the days to sexual maturity;
(2) increasing the energy and the protein reduced the feed necessary to raise a pullet;
(3) within certain limits, the growing pullet had the ability to adjust its feed intake according to its energy needs, regardless of the energy value of the ration;
(4) when the protein percentage in the growing diet was not increased, increasing the energy in the diet had no effect on egg production;
(5) when the energy in the growing diet was kept constant, increasing the protein content of the growing diet increased egg production slightly;
(6) when both the energy and the protein were increased in the growing diet, egg production was improved;
(7) increasing the protein in the growing diet increased the weight of the first egg slightly.

TABLE 34.5

PROTEIN AND ENERGY REQUIREMENTS OF LEGHORN GROWING PULLETS
(Full-fed)

Protein in Diet %	Energy per Pound of Ration		Body Weight at 21 Wk Lb	Total Feed Consumed per Pullet Lb	Age at First Egg Days	Hen-day Egg Production %	First Egg Weight Gm
	P.E. Kcal	M.E.* Kcal					
9	700	959	2.55	18.5	174	65.4	47.8
12	700	959	2.70	18.2	169	66.9	47.6
16	700	959	2.76	16.4	167	65.6	48.0
9	940	1288	2.14	11.0	179	64.9	47.3
12	940	1288	2.73	12.6	168	67.4	47.7
16	940	1288	2.94	12.3	164	67.2	47.2
20	940	1288	3.01	12.1	161	66.1	47.8
25	940	1288	2.95	12.1	160	66.1	48.1
16	1180	1616	2.93	10.9	166	66.4	47.6
20	1180	1616	2.98	10.6	160	68.4	48.0

*Estimated

The data in this table are quite indicative of results when rations varying in protein and energy are *self-fed*. Within certain confines of dietary energy, the bird has the ability to regulate its feed consumption. For example, there were three diets containing 16% protein with 700, 940, and 1180 kcal of P.E. per pound of ration, respectively. The total number of kilocalories of P.E. consumed by the three pens are shown as follows:

Protein in Diet (%)	Kcal P.E. per Pound of Ration	Total Feed Consumed per Pullet (Lb)	Total Kcal P.E. Consumed per Pullet
16	700	16 4	11,480
16	940	12 3	11,562
16	1180	10 9	12,862

ATTAINING OPTIMUM MATURE BODY WEIGHT

The importance of correct body weight during the growing period cannot be stressed too highly. Changes must be made in the feeding program, and often in the ration, so that the pullet will mature not only at an optimum body weight, but at an optimum age Although a reduction in the feed intake will delay the onset of egg production, it is better to think of the feeding program as one to maintain growing body weight, while the lighting program is to be used to delay sexual maturity. However, under practical field conditions both programs run concurrently, and each has an effect.

Optimum Mature Weight

The weight of the sexually mature egg type pullet varies with the strain of bird Added to this is the variability of individual birds within the flock, some mature earlier than others, some attain heavier weights As with all chickens, flock averages must be used in making feeding recommendations, and we may assume that most strains of Leghorns will reach sexual maturity when about 21 weeks of age and will weigh about 3 lb (1 36 kg) Medium size pullets for the production of

TABLE 34 6

EXPECTED EFFECT OF WEATHER AND LIGHT DAY ON BODY WEIGHT AT SEXUAL MATURITY (Full fed)

Weather	Light Day	Body Weight at Sexual Maturity: Leghorns Lb	Leghorns Kg	Medium size Lb	Medium size Kg
Average	Average, all conditions	3 00	1 36	4 00	1 81
Cold	Average	3 25	1 47	4 25	1 93
Hot	Average	2 75	1 25	3 75	1 70
Average	Decreasing (In season flocks)	3 25	1 47	4 25	1 93
Average	Increasing (Out of season flocks)	2 75	1 25	3 75	1 70

brown-shelled eggs will mature at the same age, with a weight of approximately 4 lb (1 81 kg). However, these optimums are not always reached If the growing pullets are self-fed, some variations expected are shown in Table 34 6

The variations in expected body weight at sexual maturity, as shown in Table 34 6, must be corrected if maximum productivity in the laying house is to be attained. The most satisfactory method is to regulate the feed intake according to the week-by-week weight of the growing birds When they are too heavy, feed intake should be reduced, when too light, the feed allocation should be increased. During some growing seasons, the air temperature and the length of the light day will be satisfactory and birds may be full-fed But when weights are not right, some method of weight control must be improvised

FEED CONTROL AND OPTIMUM MATURE WEIGHT

Feed control during the growing period varies from full feeding to some degree of feed restriction to attain a given body weight and age at sexual maturity Unfortunately, the growing pullet offers no index of how rapidly she is advancing toward the production of her first egg Growing body weight seems to be the best criterion, and is the only one available to the poultryman.

To keep most growing pullets from becoming too heavy when exposed to certain conditions, the daily feed allotment (consumption) must be reduced For this program to be effective, it is necessary to maintain the body weights on a weekly schedule beginning at eight or nine weeks of age One cannot wait until near the end of the growing period to begin to reduce the feed intake to compensate for high body weights. With meat type birds, the feed intake must be on a drastically reduced basis throughout the growing period, but egg-type pullets can withstand only moderate feed reduction The reasons are these

(1) egg-type strains have a relatively small digestive system, and feed restriction cannot be as great as with meat-type lines,

(2) egg-type strains do not respond as well to a delay in the onset of egg production when the growing diet is restricted,

(3) egg-type pullets do not lend themselves as well to prolonged feed restriction during the growing period as do meat-type pullets.

How much feed restriction? Although meat-type pullets need a feed reduction of at least 20%, egg-type birds seldom can tolerate more than 10%.

Restriction on high-energy rations There is a tendency in the field to use laying rations that are higher in energy than formerly. These will require more feed regulation to maintain the proper growing weight, particularly in cold weather when feed consumption normally increases.

METHODS OF FEED CONTROL

When the poultryman wishes to use some method of feed control to maintain required growing weights of egg type pullets, he has two alternatives.

(1) Restrict the feed intake every day.
An example would be to give the birds about 90% of their normal daily feed intake each day.

(2) Skip feeding entirely on two days each week.
No feed is given on two days each week (e.g., Sunday and Wednesday).

On feed days, however, an allocated amount of feed is to be given so that the total feed given during the week will be about 90% of what the birds would eat had they been on full-feed.

Note Although a third program of restricted feeding, SKIP EVERY-OTHER-DAY, is used for meat-type layers, the feed required on feed days for egg-type pullets is too great. It is almost impossible for the birds to consume the allocated amount of feed.

Restricted Feeding Recommendations

If restricted feeding is to be practiced with egg-type strains, remember that restriction can be only to the point that correct body weights are maintained If body weight is reduced too much by feed restriction, the daily feed allocations should be increased.

Tables 34.7 and 34 8 give *guidelines* for the above two feed control programs. *But be cautious.* First, secure the weekly growing weight recommendations for the strain of egg-type pullets you are using Most primary breeders can furnish

TABLE 34 7

BODY WEIGHT AND FEED ALLOWANCE ON FEED DAYS FOR 100 EGG TYPE GROWING PULLETS ON FEED-CONTROL PROGRAMS
(In Pounds)

	Leghorns					Medium size*				
		Full feed (Estimated)					Full feed (Estimated)			
Week	Body Weight	Feed per Day	Cum	Feed per Day	Cum	Body Weight	Feed per Day	Cum	Feed per Day	Cum
1	0 20	2 9	20	2 9	20	0 25	3 6	25	3 6	25
2	0 32	3 6	48	3 6	48	0 42	5 6	65	5 6	65
3	0 45	5 4	86	5 4	86	0 62	8 0	108	8 0	108
4	0 60	7 0	135	7 0	135	0 82	8 7	169	8 7	169
5	0 75	8 0	191	8 0	191	1 03	9 1	233	9 1	233
6	0 90	8 4	250	8 4	250	1 24	9 5	300	9 5	300
7	1 07	8 6	310	8 6	310	1 48	10 0	370	10 0	370
8	1 27	9 0	373	9 0	373	1 75	10 5	444	10 5	444
		Limited every day		Skip 2 days per week			Limited every day		Skip 2 days per week	
9	1 45	9	436	12 5	436	1 94	11	521	15 5	521
10	1 63	10	506	14	506	2 13	11 5	601	16	601
11	1 79	11	583	15 5	583	2 31	12	685	17	686
12	1 95	11	660	15 5	661	2 49	12 5	773	18	776
13	2 10	12	744	17	746	2 66	13	864	18	866
14	2 25	12	828	17	831	2 83	13 5	958	19	961
15	2 38	13	919	18 5	923	2 99	14	1056	20	1061
16	2 50	13	1010	18 5	1016	3 15	14 5	1158	20	1161
17	2 60	14	1108	20	1116	3 30	15	1263	21	1266
18	2 70	14	1206	20	1216	3 44	15 5	1371	21	1371
19	2 78	15	1311	21	1321	3 58	16	1483	22	1481
20	2 85	15	1416	21	1426	3 71	16 5	1599	22	1591
21	2 91	16	1528	22	1536	3 83	17	1718	23	1706
22	2 96	16	1640	22	1646	3 95	17 5	1840	24	1826

*Producing brown-shelled eggs.

TABLE 34.8

BODY WEIGHT AND FEED ALLOWANCE ON FEED DAYS FOR 100 EGG-TYPE GROWING PULLETS ON FEED-CONTROL PROGRAMS
(In Kilos)

	Leghorns					Medium-size*				
		Full-feed (Estimated)					Full-feed (Estimated)			
Week	Body Weight	Feed per Day	Cum.	Feed per Day	Cum.	Body Weight	Feed per Day	Cum.	Feed per Day	Cum.
1	0.09	1.32	9.0	1.32	9.0	0.11	1.60	11.3	1.60	11.3
2	0.15	1.63	21.8	1.63	21.8	0.19	2.54	29.5	2.54	29.5
3	0.20	2.45	39.0	2.45	39.0	0.28	3.63	49.0	3.63	49.0
4	0.27	3.18	61.2	3.18	61.2	0.37	3.94	76.7	3.94	76.7
5	0.34	3.63	86.6	3.63	86.6	0.47	4.13	105.7	4.13	105.7
6	0.41	3.81	113.4	3.81	113.4	0.56	4.31	136.0	4.31	136.0
7	0.49	3.90	140.6	3.90	140.6	0.67	4.54	167.8	4.54	167.8
8	0.58	4.08	169.2	4.08	169.2	0.79	4.76	201.4	4.76	201.4
		Limited every day		Skip 2 days per week			Limited every day		Skip 2 days per week	
9	0.66	4.08	197.8	5.67	197.8	0.87	4.99	236.3	7.03	236.3
10	0.74	4.54	229.5	6.35	229.5	0.97	5.22	272.6	7.26	272.6
11	0.81	4.99	264.4	7.03	264.4	1.05	5.44	310.7	7.71	311.2
12	0.88	4.99	299.4	7.03	299.8	1.13	5.67	350.6	8.17	352.0
13	0.95	5.44	337.5	7.71	338.4	1.21	5.90	391.9	8.17	392.8
14	1.02	5.44	375.6	7.71	376.9	1.28	6.12	434.5	8.62	435.9
15	1.08	5.90	416.9	8.39	418.7	1.36	6.35	479.0	9.07	460.9
16	1.13	5.90	458.1	8.39	460.9	1.43	6.58	525.3	9.07	526.6
17	1.18	6.35	502.6	9.07	506.2	1.50	6.80	572.9	9.53	574.3
18	1.22	6.35	547.0	9.07	551.6	1.56	7.03	621.9	9.53	621.9
19	1.26	6.80	594.7	9.53	599.2	1.62	7.26	672.7	9.98	671.8
20	1.29	6.80	642.3	9.53	646.8	1.68	7.48	725.3	9.98	721.7
21	1.32	7.26	693.1	9.98	696.7	1.74	7.71	779.3	10.43	773.8
22	1.34	7.26	743.9	9.98	746.6	1.79	7.94	834.6	10.89	828.3

*Producing brown-shelled eggs.

these. Then govern the daily feed allocations so that these weights will be maintained. It may be necessary to alter the figures given in Tables 34.7 and 34.8 in order to accomplish this.

Notes on the Controlled Feeding Programs

(1) Full-feed the starter until the chicks are five weeks of age.
(2) Full-feed the grower during the sixth, seventh, and eighth weeks.
(3) Begin the controlled feeding program at the beginning of the ninth week (57 days).
(4) The suggested amount of feed control will reduce the body weight at 20 weeks of age by about 5 to 10% when compared with the body weight of birds given full feed. Medium-size lines must have a greater percentage of weight reduction than Leghorns.
(5) Growing rations should involve phase feeding. See Table 34.4. If the available growing rations have an energy content lower than those given in this table, the daily feed allocation must be *increased* proportionately.

(6) Formula adjustments in the growing ration may have to be made to compensate for differences in feed consumption during hot, normal, and cold weather

(7) When any program of feed control is used, be sure to have adequate feeding space All pullets should be able to eat at one time See Chapter 14 Run the automatic feeders continuously until the daily feed allocation is consumed

How to Increase and Decrease Feed Intake

When growing pullets are underweight at any particular week, the feed allotment must be increased, when they are overweight, it must be decreased Normally, these changes will not be too great if the birds have been "on schedule" during their previous weeks of growth

Rule of thumb For each 1% overweight, decrease the weekly feed consumption by 1% If underweight, increase the weekly feed intake by 1%

Feeding During Stress

Stresses created by vaccination, debeaking, disease, high and low temperatures, and moving must be compensated for in the feeding program When stresses occur, return the birds to full feeding and continue with this program until they recover, then gradually reduce the feed intake to the control recommendations

Stress and low protein rations Low protein rations do not produce quick recovery when the birds are subjected to severe and prolonged stresses The difficulty is that under such conditions feed consumption is drastically reduced, even when the pullets are self fed, thus reducing the daily intake of protein In such circumstances, it is advisable to feed a ration higher in protein

Anticipating stresses Many times it will be obvious that certain management procedures, debeaking, vaccinating, moving, etc , are going to create a stress Full feed for about 2 or 3 days before such procedures and for a like period afterward

GROWING FEED FORMULA VARIATIONS

Although controlled feeding during the growing period makes it possible to maintain optimum growing body weight, at times this is not the most economical program Adjustments in the basic feed formula must be made to supplement feed restriction

Hot vs cold weather It must be kept in mind that during hot weather, birds of all types require less energy to maintain their body temperature than during cold weather If the caloric content of the diet remains the same, birds will eat less feed when the environmental temperature rises

Rule of thumb The basic rule for birds of all types and ages is that birds will consume 1% less feed for each 1° F rise in temperature

If the above rule is applied further, it means that each 1% decrease in feed consumption also decreases the protein consumed per day by 1% Protein consumption becomes the limiting factor, not energy, and the ration must be altered

Daily Protein Consumption During Growth

The growing bird's need for protein is low, and because she regulates her feed intake according to the temperature, the daily protein intake becomes important. Regardless of how many calories of energy she consumes each day, her protein requirement remains fairly constant.

Measurement of protein consumption: Protein is measured as the grams of total protein consumed per bird. It may be computed on a daily, per pound, per kilo, or other basis.

Protein consumption calculated: If Table 34.7 is used as the basis for daily feed consumption for Leghorn growing pullets, the daily protein consumption may be calculated, as shown in Table 34.9. Important points are:

(1) Feed consumption per bird per day more than doubles between the 4th and the 20th weeks.

TABLE 34.9

CALCULATED DAILY PROTEIN CONSUMPTION OF LEGHORN PULLETS

Week	Weight of Bird Lb	Protein in the Ration %	Feed Consumed per Bird per Day* Gm	Protein Consumed per Bird per Day Gm	Protein Consumed per Pound of Body Weight per Day Gm
4	0.60	21	31.8	6.7	11.1
8	1.07	17	40.8	6.9	6.5
12	1.95	15	49.9	7.5	3.9
16	2.50	13	59.0	7.7	3.1
20	2.85	13	68.0	8.8	3.1

*Limited every day feeding program.

(2) When phase feeding and some control are used, the amount of protein consumed per bird per day rises only slightly during the same period.

(3) However, from four weeks to maturity, the protein consumed per pound of body weight per day is greatly reduced.

Protein requirement per day: The daily protein requirement of a growing egg-type pullet is as follows:

Leghorn: 7 to 8 gm
Medium-size: 8 to 9 gm

Equalizing the protein intake: To maintain a constant daily intake of protein per bird when the temperature increases, there are two recommendations:

(1) *Decrease the energy content of the ration:* Decreasing the energy content will cause the birds to eat more feed, thus increasing the daily protein consumption.

(2) *Increase the protein content of the ration:* To maintain daily protein consumption as the temperature rises, the percentage protein in the ration may be increased, since feed consumption will drop.

Rule of thumb The rule of thumb for making the above two adjustments is to decrease the energy content of the ration by 1% or increase the protein by 1% of the total protein for each 1° F rise in temperature Reverse when the temperature drops below 70° F

Floor vs cage birds As birds in cages exercise less than those on a littered floor, their energy requirement is less, and they eat less feed To adjust the feed formula in these cases, decrease the caloric value of the cage feed or increase the protein percentage Usually, the former is more economical unless a low-energy feed is already involved

Out-of season flocks These are flocks that are raised during increasing lengths of light day They mature early If self fed, the early maturity will cause them to increase their feed consumption during the latter part of the growing period Little can be done to offset the situation by changing the feed formula Feed restriction is the salvation here, because it delays the onset of egg production

Started pullets Most started pullets are sold several weeks prior to the onset of egg production This is often an awkward age for chickens, they are not fully feathered and have not "combed up" Although no special formulas are used to produce started pullets, the need for well developed pullets is obvious Excessive feed restriction cannot be used during the growing period

FEED SUPPLEMENTS

Several feed supplements are often fed to growing pullets These are fed separately from the well formulated starter and grower rations The merits of these are as follows

Grit When pullets are being raised on a littered floor, feed 1 lb (454 gm) of grit per 100 birds per week If on wire or slats, feed 1 lb (454 gm) per 100 birds every 6 weeks When skip-a-day feeding programs are used, feed the grit on some day that feed is given Do not feed the week's allotment of grit on a day when no feed is given

Oystershell The growing feed should be complete, including the necessary calcium However, as the pullets approach egg production, additional calcium must be supplied Directions for this procedure are given in Chapter 35

Whole grain In the past, many skip a-day feeding programs called for the feeding of a small amount of whole oats in the litter on the days when "no feed" was given, in an endeavor to give the birds something to do on these days Nutritionally, the practice has no merit, and because of the labor, the procedure has been terminated

Feeding Laying Hens

Today, most commercial layers are kept in cages rather than on a littered floor, as was the custom a few years ago This method of management has necessitated some changes in laying feed formulas and in feeding methods Except where otherwise noted, this chapter deals with the caged layer

Approximately 57% of the cost of producing a dozen eggs is for feed Therefore, feed management is a most important economic consideration Everything should be geared to the least feed cost per dozen eggs produced

Experimental evidence has shown that strains of laying birds differ in their feed requirements Most of these variations have to do with daily feed consumption, as some strains are larger or smaller than others, but there is little evidence to show that changes must be made in the feed formula There is more variation in the weight of the birds within a given flock than between strains Correct nutrition for the individual bird is more important than for the strain One must feed to satisfy the requirements of the largest bird and the best egg producer in the flock Smaller birds and poorer producers naturally utilize feed ingredients in a less efficient manner, there is some wastage, as it is impossible to balance the diet of every individual

Basic Requirements For Laying Hens

(1) *Body maintenance* The pounds of feed necessary for body maintenance vary with the weight of the bird Approximations for a diet of average energy content are shown in Table 35 1, expressed as the pounds of feed necessary per pound of body weight and per bird per month

TABLE 35 1

FEED REQUIREMENT FOR MAINTENANCE

Weight of Hen Lb	Pounds of Feed Required for Maintenance per Month	
	per Pound of Body weight	per Bird
3	1 31	3 9
4	1 17	4 7
5	1 08	5 4
6	1 02	6 1
7	0 94	6 6

(2) *Body growth* A Leghorn pullet should gain from 1 to 1 25 lb (454-567 gm) during her laying year A medium size layer (producing brown shelled eggs) should gain about 0 25 lb more than this

(3) *Feather production*

(4) *Egg production* The feed requirement for the production of eggs is determined by the number and size of the eggs laid

ENERGY FOR EGG PRODUCTION

The number of calories of energy in a laying ration is highly variable, as will be pointed out Furthermore, the daily feed consumption is far from consistent throughout the egg production period Not only does the weight of the layer influence consumption, but birds must also gain weight, and this gain in weight is not uniform Detailed tests have shown that practically all individual birds have periods of weight gain followed by intervals when they gain no weight From a flock standpoint, however, there should be some weekly increases in body size

Energy Requirement

The metabolizable energy (M E) requirement of a 4 lb (1 8 kg) layer, kept at a moderate temperature, and laying at the rate of 75% hen-day production, is about 300 to 310 kcal per day The figure will increase in cold weather and decrease in hot weather

TABLE 35 2

DIETARY ENERGY IN THE FEED AND DAILY FEED REQUIREMENT
(Moderate Temperature)
(Four-pound hen)

Kilocalories of M.E per Lb of Ration	Feed Required per Day per 100 Hens to Supply 306 Kcal M E per Hen Lb	Feed per Dozen Eggs Produced* Lb
1200	25 5	4 1
1250	24 5	3 9
1300	23 5	3 8
1350	22 7	3 6
1400	21 9	3 5
1450	21 1	3 4

*75% hen-day egg production

The amount of energy in the diet will control feed consumption The relationship is shown in Table 35 2, which gives feed consumption necessary per day as the caloric content of the ration varies

Note The figures in Table 35 2 are calculated Actually under field conditions the rations higher in energy will be more efficient than those lower in energy

Environmental Temperature and Feed Consumption

As the hen's requirement for energy is higher in cold weather than in hot weather, there are differences in the amount of feed she consumes under these conditions These variations are shown in Table 35 3

PROTEIN FOR EGG PRODUCTION

To speak of the protein requirement for egg production is to speak of the amino acid requirement Protein must be well balanced and of high quality for a hen to

TABLE 35 3

TEMPERATURE AND WIEGHT OF BIRDS AS THEY AFFECT ENERGY AND FEED REQUIREMENT

Environmental Average Day time House Temperature	Weight of Laying Hens							
	3 Lb		4 Lb		5 Lb		6 Lb	
	Feed per Day per 100 Hens* Lb	M E per Hen per Day Kcal	Feed per Day per 100 Hens* Lb	M E per Hen per Day Kcal	Feed per Day per 100 Hens* Lb	M E per Hen per Day Kcal	Feed per Day per 100 Hens* Lb	M E per Hen per Day Kcal
Moderate (65°-70°F)	20 7	280	22 7	306	24 7	333	26 7	360
Cold (50°-55°)	23 8	321	26 1	352	28 4	383	30 7	414
Hot (85° 95°)	17 6	238	19 2	260	20 9	282	22 7	307

*Diet containing 1350 kcal/lb

lay her maximum number of eggs, and to produce them economically. Of the amino acids often deficient in the laying ration, methionine is most commonly involved.

Grams of Protein as an Index

As the kilocalorie is the basis for measuring energy, the gram is the unit used for measuring protein. Grams of protein must be thought of as grams of quality protein, when the protein is of marginal quality, the hen's daily requirement for total protein will be higher

Daily Protein Requirement

The need for protein for egg production is closely associated with the hen's rate of egg production, since her requirements for maintenance and growth during the laying period are relatively low.

To attain a perspective of the amount of protein required for only the production of eggs, Table 35 4 is presented This table is calculated on the basis that 12% of the whole egg (including shell) is protein and that the hen has the ability to utilize 55% of the protein consumed for the production of egg protein The table

TABLE 35 4

GRAMS OF DIETARY PROTEIN REQUIRED PER DAY FOR EGGS AS INFLUENCED BY EGG SIZE AND EGG PRODUCTION

Egg Size		Grams of Protein per Egg	Grams of Dietary Protein Necessary for Egg Protein, per Egg**	Percent Hen day Egg Production			
				90	80	70	60
				Grams of Protein Required per Hen per Day**			
Oz/Doz	Gm/ea						
28	66 1	7 9	14 4	13 0	11 5	10 0	8 6
26	61 4	7 4	13 5	12 1	10 8	9 5	8 1
24	56 7	6 8	12 4	11 2	9 9	8 7	7 4
22	52 0	6 2	11 3	10 2	9 0	7 9	6 8
20	47 2	5 7	10 4	9 4	8 3	7 3	6 2

*At 55% efficiency
**Grams of protein for egg production only, when computed on flock average

shows the grams of protein needed per bird per day according to her egg size and rate of egg production

Besides the protein needed for the actual production of eggs, there is also the requirement of body maintenance, growth, and feather production during the laying year Again these total to a variable figure because of differences in the rate of egg production and the body weight A close approximation of these requirements is given in Table 35 5

TABLE 35.5

DIETARY PROTEIN REQUIREMENT ACCORDING TO RATE OF EGG PRODUCTION

Breed	Percent Hen day Egg Production				
	90	80	70	60	50
	Total Grams of Dietary Protein Required per Hen per Day*				
Leghorn	18	17	16	15	14
Medium size	20	19	18	17	16

*Moderate weather

Practical application As a hen begins her laying year she has a low rate of egg production of small eggs, her size is small, but she gains weight rapidly When her egg production peaks, the bird is heavier, her egg size larger, but her rate of growth begins to diminish As she continues her laying year, egg production drops, egg size increases, and growth is minor These variations in bird behavior alter the daily protein requirement for each variable, but when totaled, the protein requirement is closely related to egg production Thus from a practical standpoint, the table associates protein need only with the rate of egg production, but the other variables are considered

Protein requirement at peak of egg production Undoubtedly the bird's demand for protein is high when flock egg production peaks at seven to eight weeks after it produces the first egg But offsetting this high demand is the fact that both the bird and her eggs are small The recommendation that 18 gm of protein per Leghorn hen per day during this peak in egg production are adequate is not substantiated by all scientists Some feel that it should be as high as 19 or 20, and probably the higher figures are mathematically correct However, hundreds of flocks of Leghorns reach satisfactory peaks of production on less than 18 grams Recent evidence points to the fact that the layer has the ability to use some of her tissue protein for the production of eggs This could be a partial source of protein in these cases

As usual, the recommendation is based on a flock average, and it could be that 18 grams of protein per day will not satisfy the requirement of the larger birds within the flock Furthermore, the weight of the bird at sexual maturity has a definite bearing If she is overweight at this time, the protein demand will be greater at peak of production However, more and more birds are grown on controlled feeding programs and, as a result, pullets mature at a lighter weight than normal

Feed Necessary to Supply Protein

The amount of feed per day necessary to furnish the required daily protein is given in Table 35.6 according to the percentage of protein in the ration.

Important: Seldom will 100 Leghorn laying hens weighing 4 lb (1.8 kg) eat more than 26 lb per day when the weather is moderate.

TABLE 35.6

POUNDS OF FEED NECESSARY TO SUPPLY DAILY PROTEIN REQUIREMENT OF LAYING HENS

% Protein in Ration	Grams of Protein Required per Hen per Day						
	20	19	18	17	16	15	14
	Pounds of Feed Required per 100 Hens per Day*						
20	22.0	20.9	19.8	18.7	17.6	16.5	15.4
19	23.2	22.0	20.9	19.7	18.6	17.4	16.2
18	24.5	23.3	22.0	20.8	19.6	18.4	17.1
17	25.9	24.6	23.3	22.0	20.7	19.4	18.1
16	27.5	26.2	24.8	23.4	22.0	20.7	19.3
15	29.4	27.9	26.4	25.0	23.5	22.0	20.6
14	31.5	29.9	28.3	26.8	25.2	23.6	22.0

*Moderate weather.

Feed Consumption as it Relates to Protein Consumption

If the feed consumption per 100 hens per day and the percentage of protein in the diet are known, it is possible to calculate the daily intake of protein in grams. These figures are given in Table 35.7. As an example, if the birds were eating 25 lb (11.3 kg) of feed per 100 hens per day, and the ration contained 16% protein, the protein consumed per bird per day would be 18 gm.

TABLE 35.7

GRAMS OF PROTEIN CONSUMED PER BIRD PER DAY ACCORDING TO FEED CONSUMPTION AND PERCENT PROTEIN IN THE RATION

Feed per 100 pullets per Day Lb	Kg	Percent Protein in Laying Ration						
		14	15	16	17	18	19	20
		Grams of Protein Consumed per Bird per Day						
18	8.2				14	15	16	16
19	8.6			14	15	16	16	17
20	9.1		14	15	15	16	17	18
21	9.5		14	15	16	17	18	19
22	10.0	14	15	16	17	18	19	20
23	10.4	15	16	17	18	19	20	21
24	10.9	15	16	17	19	20	21	22
25	11.3	16	17	18	19	20	22	23
26	11.8	17	18	19	20	21	22	
27	12.2	17	18	20	21	22	23	
28	12.7	18	19	20	22	23		
29	13.2	18	20	21	22			
30	13.6	19	20	22	23			
31	14.1	20	21	23				

Protein Intake and Egg Size

There is abundant experimental evidence in print to substantiate the fact that raising the percentage of protein in the ration, which would raise the daily intake per bird, increases egg size It is doubtful, however, if increases above the figures given in Table 35 5 will be of value Certainly, any decrease in the figures would reduce egg size

MINERALS FOR EGG PRODUCTION

During the growing period, the diet should contain approximately 0 9% calcium and 0 6% total phosphorus But once egg production begins, the need for calcium is much greater because of eggshell formation The relationships are given in Chapter 27 Of particular importance is the fact that too much calcium is detrimental, it depresses the appetite Besides, surpluses are excreted in the fecal material

Only a portion of the calcium fed to a laying hen is retained by the bird, the balance being excreted The retention is about 60% for young laying hens, and 40% for older layers

Of equal importance is the fact that calcium increase from the growing need to the laying need must begin only one week before the time the first egg is laid The usual procedure is to self feed oystershell at this time and continue for about two weeks after the first egg is produced

Calcium requirement of the laying hen The dietary calcium requirement is related to the percentage retained by the bird and to the rate of egg production Although subject to some variation according to environmental temperature and the period during which eggs are laid, the daily calcium intake requirement per bird is as follows

Percent Egg Production	Grams of Calcium Required per Bird per Day	
	Leghorn	Medium-size
90	4 0	4.3
80	3 6	3 9
70	3 1	3 4
60	2 7	3 0
50	2.2	2 5

Example If the flock is consuming 22 lb (9.98 kg) of feed per 100 birds per day, each bird is eating approximately 100 gm of feed Therefore, if egg production were 70%, it would require 3.1% calcium in the Leghorn ration to furnish 3 1 gm of calcium per hen per day

As feed consumption increases with higher egg production, calcium consumption also increases, even though the percentage in the feed formula remains the same

Seasonal variation in calcium consumption If a ration composed of a fixed percentage of calcium and energy is fed throughout the laying year there will be less feed consumed during hot weather, thus reducing the daily amount of calcium consumed Therefore, unless the energy portion of the ration is corrected for environmental temperature variations, the summer

ration should contain a higher percentage of calcium and the winter ration a lower percentage

The phosphorus requirement for the laying bird is about 450 mg per day for birds kept on littered floors and 550 mg when the birds are in cages This amount is satisfied when the laying ration contains about 0 6% total phosphorus

CHANGING FROM GROWING TO LAYING RATIONS

At the time egg production begins, several things are of importance

(1) It is necessary to change from a growing to a laying ration
(2) A form of calcium carbonate must be self fed for a three week period to increase the calcium reserve in the medullary bone
(3) The daily feed intake must increase
(4) The birds gain weight rapidly until the peak of egg production
(5) The lighting program must be altered

Rules During the Change

Although a change from the growing to the laying ration is obvious, the poultryman must follow certain rules to make the changeover with as little stress as possible The rules to be followed chronologically are

Week of age	Day of age	Management change
20	140	Self feed oystershell Add the shell to the mash when birds are caged
21	147	Increase the light day to 13 or 14 hours, depending on the light hours during the growing period See Chapter 18
21	147	Change from grower to layer ration, but continue controlled feeding if that has been the growing program
21	147	Flock should lay first eggs (1 to 2% production)
22	154	If growing controlled feeding is being used, change to full feeding Increase the feed 1 lb (454 gm) per 100 birds per day until on full feed
22	154	Increase the light day by 1 hour, with a maximum light day of 16 hours
22	154	Flock should reach 5% hen-day egg production
23	161	Birds should be on full feed
23	161	Discontinue free-choice feeding of oystershell

Notes on the feed changeover program It is important that the stimulation from an increase in the length of light day coincide with a change from controlled feeding to full feeding When full feeding precedes light stimulation, birds progress into egg production too slowly and their early increase in body weight is too great When full feeding follows light stimulation, pullets are forced to lay without the necessary feed components to produce the eggs

The days mentioned in the procedures are based on flocks that are to lay their first eggs at 21 weeks (147 days) of age When egg production is to begin at an earlier or later age, the program should be shifted appropriately

FEED REQUIREMENT

As has been shown, the daily feed requirement for egg production is based on the energy and protein requirement Furthermore, the bird varies her feed intake according to her caloric need, thus affecting the amount of protein consumed To

TABLE 35.8

FEED CONSUMPTION PER 100 LAYING LEGHORN HENS PER DAY*
(Hen day Basis)

Week of Egg Production	Feed Consumed				Week of Egg Production	Feed Consumed			
	Per 100 Hens per Day		Cumulative per Hen			Per 100 Hens per Day		Cumulative per Hen	
	Lb	Kg	Lb	Kg		Lb	Kg	Lb	Kg
1	17	7 7	1 2	0 5	27	23	10 4	43 7	19 8
2	21	9 5	2 7	1 2	28	23	10 4	45 3	20 5
3	23	10 4	4 3	2 0	29	23	10 4	46 9	21 3
4	24	10 9	6 0	2 7	30	23	10 4	48 5	22 0
5	24	10 9	7 6	3 5	31	23	10 4	50 1	22 7
6	24	10 9	9 3	4 2	32	23	10 4	51 7	23 5
7	24	10 9	11 0	5 0	33	23	10 4	53 3	24 2
8	24	10 9	12 7	5 8	34	23	10 4	55 0	25 0
9	24	10 9	14 4	6 5	35	23	10 4	56 6	25 7
10	24	10 9	16 0	7 3	36	23	10 4	58 2	26 4
11	24	10 9	17 7	8 0	37	23	10 4	59 8	27 1
12	24	10 9	19 4	8 8	38	23	10 4	61 4	27 9
13	24	10 9	21 1	9 6	39	22	10 0	62 9	28 5
14	24	10 9	22 8	10 3	40	22	10 0	64 5	29 3
15	23	10 4	24 4	11 1	41	22	10 0	66 1	30 0
16	23	10 4	26 0	11 8	42	22	10 0	67 6	30 7
17	23	10 4	27 6	12 5	43	22	10 0	69 2	31 4
18	23	10 4	29 2	13 2	44	22	10 0	70 7	32 1
19	23	10 4	30 8	14 0	45	22	10 0	72 3	32 8
20	23	10 4	32 4	14 7	46	22	10 0	73 8	33 5
21	23	10 4	34 0	15 4	47	22	10 0	75 3	34 2
22	23	10 4	35 6	16 1	48	22	10 0	76 9	35 9
23	23	10 4	37 2	16 9	49	22	10 0	78 4	35 6
24	23	10 4	38 9	17 6	50	21	9 5	79 9	36 2
25	23	10 4	40 5	18 4	51	21	9 5	81 4	36 9
26	23	10 4	42 1	19 0	52	21	9 5	82 8	37 6

*Moderate weather

show the weekly feed intake for all conditions to which the flock is subjected, and for all strains, is an impossibility. Only average figures can be itemized; and these are given in Tables 35.8 and 35.9, as feed consumption when hens are on full feed during moderate weather.

Notes on Tables 35.8 and 35.9:

(1) Feed consumption is based on pullets that are *raised* on a minimum of feed, entailing some feed restriction. If the growing pullet is full-fed she will be heavier at the onset of lay and will consume more feed during the laying period.

(2) The figures for feed consumption during the *laying period* involve full feeding for Leghorns and restricted feeding for medium-size hens. Under field conditions, medium-size layers should be fed so they consume only slightly more feed than Leghorns.

Note: When medium-size layers are *full-fed* they will consume approximately 15% more feed than Leghorns *full-fed.*

(3) Figures are on a hen-day basis, meaning the amount of feed consumed by the live birds per day.

TABLE 35.9

FEED CONSUMPTION PER 100 LAYING MEDIUM-SIZE HENS PER DAY*
(Hen-day Basis)

Week of Egg Production	Feed Consumed				Week of Egg Production	Feed Consumed			
	Per 100 Hens per Day		Cumulative per Hen			Per 100 Hens per Day		Cumulative per Hen	
	Lb	Kg	Lb	Kg		Lb	Kg	Lb	Kg
1	18	7.7	1.3	0.6	27	24	10.9	45.5	20.6
2	22	10.0	2.8	1.3	28	24	10.9	47.2	21.4
3	24	10.9	4.5	2.0	29	24	10.9	48.9	22.2
4	25	11.3	6.2	2.8	30	24	10.9	50.5	22.9
5	25	11.3	8.0	3.6	31	24	10.9	52.2	23.7
6	25	11.3	9.7	4.4	32	24	10.9	53.9	24.5
7	25	11.3	11.5	5.2	33	24	10.9	55.6	25.2
8	25	11.3	13.2	6.0	34	24	10.9	57.3	26.0
9	25	11.3	15.0	6.8	35	24	10.9	58.9	26.7
10	25	11.3	16.7	7.6	36	24	10.9	60.6	27.5
11	25	11.3	18.5	8.4	37	24	10.9	62.3	28.3
12	25	11.3	20.2	9.2	38	24	10.9	64.0	29.0
13	25	11.3	22.0	10.0	39	23	10.4	65.6	29.8
14	24	10.9	23.7	10.8	40	23	10.4	67.2	30.5
15	24	10.9	25.3	11.5	41	23	10.4	68.9	31.3
16	24	10.9	27.0	12.2	42	23	10.4	70.5	32.0
17	24	10.9	28.7	13.0	43	23	10.4	72.1	32.7
18	24	10.9	30.4	13.8	44	23	10.4	73.7	33.4
19	24	10.9	32.1	14.6	45	23	10.4	75.3	34.2
20	24	10.9	33.7	15.3	46	23	10.4	76.9	34.9
21	24	10.9	35.4	16.1	47	23	10.4	78.5	35.6
22	24	10.9	37.1	16.8	48	23	10.4	80.2	36.4
23	24	10.9	38.8	17.6	49	23	10.4	81.8	37.1
24	24	10.9	40.5	18.4	50	22	10.0	83.3	37.8
25	24	10.9	42.1	19.1	51	22	10.0	84.8	38.5
26	24	10.9	43.8	19.9	52	22	10.0	86.4	39.2

*Moderate weather.

(4) Statistics from the two tables are

Item	Leghorn	Medium size
Eggs per hen per year (hen-day)	259	251
Feed consumed per year (hen-day) (lb)	82 8	86 4
Feed consumed per year (hen day) (kg)	*37 6*	*39 2*
Feed consumed per doz eggs (hen-day) (lb)	3 83	4 13
Feed consumed per doz eggs (hen day) (kg)	*1 74*	*1 87*

PHASE FEEDING

Because of reduced rate of lay as the bird continues through her laying year, less protein is required per day by the commercial layer Since the bird eats approximately the same amount of feed each day during this period, it is practical to reduce the percentage of protein in the diet See Chapter 30 and Table 35 5 Although this procedure, known as phase feeding, does not improve the rate of lay, it does prevent waste of protein and lowers the cost of producing a dozen eggs

Number of Feeding Phases

To be practical, three feeds usually should be employed during the laying period to reduce the percentage of protein The feeds are associated with three periods known as *phases*

Phase I From day of first egg through 20 weeks of egg production
Phase II Beginning the 21st week through the 40th week of egg production
Phase III After the 40th week of egg production

Importance of Phase I The first 20 weeks of egg production are important from a nutritional standpoint During this period the bird will peak in egg production With today's feeding programs, this peak should come at about the seventh or eighth week after egg production starts On a flock basis, the peak should come the sixth week after the flock attains 5% egg production on a hen-housed basis Flocks peak much earlier and more abruptly with today's management programs than they did a few years ago

At the peak of egg production, better than 90% egg production will be achieved by most strains of birds This requires somewhat more than 18 gm of dietary protein per bird per day, including that necessary for growth and feather production In all probability the figure should be larger to satisfy the larger birds in the flock

Analysis of a Three-phase Feeding Program

The nutritional implications of a three phase feeding program for Leghorn layers are shown in Table 35 10 Notice how well this fits the nutritional require ments of hens kept under moderate temperatures Caloric consumption and pro tein intake are very close to the bird's requirement based on age and egg production There is little waste of protein

Phase Feeding When the Temperature Changes

The data given in Table 35 10 pertain to moderate house temperatures, but when the temperature changes, the feed formula recommendations must be

TABLE 35 10

ANALYSIS OF PHASE FEEDING PROGRAMS FOR LEGHORN LAYERS BY WEEKS OF EGG PRODUCTION
(Moderate Weather)

Item	Phase Feeding Period I 1 through 20 Wk	Phase Feeding Period II 21 through 40 Wk	Phase Feeding Period III Over 40 Wk
% protein in ration	18 0	16 5	15 0
Kcal of M E per lb of ration	1300	1300	1300
Kcal of M E per kg of ration	*2860*	*2860*	*2860*
Kcal of M E consumed per hen per day	302	298	283
% egg production at peak production	90+	—	—
Avg % egg production (hen day)	74 2	73 5	61 5
Avg feed consumer per hen per day (lb)	0 232	0 229	0 218
Avg feed consumed per hen per day (gm)	*105*	*104*	*99*
Avg grams of protein consumed per hen per day	*18 9*	*17 2*	*14 9*

corrected The main change has to do with the energy content of the feed and the fact that birds eat less as the temperature rises. It becomes necessary to alter the caloric value of the feed slightly, but changes in the protein and calcium content of the diet must be more drastic to prevent a nutritional deficiency. Recommendations for these alterations are given in Table 35.11.

TABLE 35 11

PHASE FEEDING FOR TEMPERATURE VARIATIONS

Environmental Temperature	Phase I 1-20 Wk Kcal M E per Lb	Phase I % Protein	Phase I % Ca	Phase II 20-40 Wk Kcal M E per Lb	Phase II % Protein	Phase II % Ca	Phase III Over 40 Wk Kcal M E per Lb	Phase III % Protein	Phase III % Ca
	Phase Feeding Period during Egg Production — Amount in Feed								
Moderate (65°-70°F)	1300	18 0	3 2	1300	16 5	3 2	1300	15 0	3 4
Cold (50°-55°F)	1400	17 0	3 0	1400	15 5	3 0	1400	14 0	3 2
Hot (85°-95°F)	1200	19 0	3 4	1200	17 5	3 4	1200	16 0	3 7

CONTROLLED FEEDING OF LAYERS

Normally, the feed intake of Leghorns is not restricted during the laying period. But if feed changes have not been made during periods of hot and cold weather, birds may become underweight or overweight. In these instances it may be advisable to control the feed intake so as to maintain the optimum body weights.

With medium-size layers (producing brown-shelled eggs) there is evidence to support the theory that some feed restriction during the laying period is necessary. These lines have a tendency to get overweight easily, and they seem to lay as well at lighter weights. Extreme care should be taken to regulate the feed intake during their laying year so as to maintain optimum body weights.

Limited Time Feeding

This procedure, developed at the Washington Experiment Station, involves a restriction in the number of hours each day that the layers have access to feed Birds are allowed full feed during the feeding hours, no daily feed allocation is given Data show that feed consumption may be reduced by about 10% without sacrificing egg production or egg size

Recommendation Full feed until 2 weeks after the peak of egg production, then full feed for 2 hours in mid morning and 2 hours in mid-afternoon

Feeding Breeding Birds

Breeding birds comprise both egg type and meat type strains, and although the feed formulas for these two types are quite similar, actual feeding procedures are vastly different during the growing and egg production periods because meat-type birds tend to become obese, while egg-type birds usually do not get overly fat when growing or when producing eggs

FEEDING DURING THE STARTING PERIOD

The starter ration for breeder type chicks should be approximately the same as that for commercial egg type chicks, and should be self-fed for the first 5 or 6 weeks Mash or crumbles may be fed

Length of the Starting Period

The exact length of time the starter should be fed to breeder type chicks will be determined to some extent by the protein content of the growing ration When it is low in protein, the starter should be fed for a longer period

In the case of meat lines, the males usually are raised separately from the females, because some selection pressure will be required at 6 to 8 weeks of age, and this is more easily carried out when the sexes are not mixed Normally, the starter ration is self fed until the selection is completed

FEEDING EGG-TYPE BREEDERS DURING GROWING

Most egg type growing breeders are raised on a littered floor, although some are kept on slats or wire However, the type of floor will alter the nutritional growing program but little The growing feed formula for egg type breeders should be the same as that for commercial egg type pullets

Female Feed Allocations

As most parent line, egg type breeder females have approximately the same body weight as their female offspring, feed allocations during growing are approximately the same However, close adherence to the primary breeder's recommendation for body weight during the growing period of the female should be followed This may or may not necessitate some feed control

Male Feed Allocations

Common procedure during the growing period is to keep the cockerels with the pullets Thus, both sexes have access to the same feed Growing males of the egg type group seldom will get too heavy if some program of maintaining the correct female weight is followed

Feed Consumption

When the males are with the females, there are two methods of measuring feed consumption of a flock

(1) *Per bird basis* This is the total feed consumed divided by the number

of birds (males plus females) in the pen. This procedure is used for growing birds.

(2) *Per pullet basis.* This is the total feed consumed divided by the number of females in the pen, and expressed as *feed consumed per female.* Therefore, the male feed is included in the "female" feed. *This is the index used in this chapter for laying birds.*

Feed consumption figures for egg-type commercial females are given in Table 34.7. These may be used on a bird basis for both male and female growing breeders.

FEEDING MEAT-TYPE BREEDERS DURING GROWING

Meat-type breeder females producing broiler offspring possess the inherent ability to grow rapidly. When full fed during the growing period they gain excessive weight and lay down too much fat for maximum productivity during the laying period. The body weight must be drastically reduced during the growing period.

Reduced Weight at Sexual Maturity

The real object of restricting the caloric intake of meat-type breeder females during the growing period is to produce a pullet that is smaller when she lays her first eggs, although restriction also delays the onset of egg production. The process of weight reduction must encompass the entire growing period; one cannot wait until just before egg production begins.

What Growing Feed Restriction Does

As early as 1937, it was found that restricting the feed intake of the growing bird would delay sexual maturity and increase the size of the first eggs laid. From this early beginning the method of feed restriction has been improved; today, the results from the program show:

(1) Restricting the growing feed intake will delay the onset of sexual maturity from a few days to 3 or 4 weeks, depending on the severity of restriction.

(2) Feed restriction will reduce the body weight of the bird at sexual maturity.

(3) Mortality during the growing period is not normally affected unless the feed restriction approaches starvation.

(4) Restriction of an ordinary growing diet may lead to nutritional deficiencies because all feed components are restricted.

(5) Restricting the feed intake usually means that the cost of raising a pullet is reduced, but this is not necessarily true under all conditions. The additional time necessary to reach sexual maturity may involve the use of more feed.

(6) Restricting the feed intake during the growing period usually produces better livability during egg production.

(7) Egg production is not greatly affected during an equal number of months of lay, regardless of any growing program of feed restriction.

(8) Egg weight is regulated by the age of the bird. Therefore, birds grown on feed restriction will produce larger first eggs only because they are older.

Reducing the Daily Caloric Intake

Although restriction of the weekly feed consumption is predominately to reduce the average daily caloric intake, it is not the only procedure that can be used. High-fiber diets, reducing the daily feeding time, imbalanced rations, and other methods have been used. But these have led to difficulties at times; practically all commercial poultrymen rely on feed restriction.

How much feed restriction? Most strains of meat-type breeder pullets will reach a weight of about 7.25 lb (3.3 kg) at sexual maturity when they are full-fed during the growing period. Individual birds will be even heavier. For top performance during the laying period, a flock of pullets should have an average weight of about 5.3 to 5.5 lb (2.4–2.5 kg) at sexual maturity. This means a weight approximately 25% below that of pullets full-fed. To produce this reduction, there must be a feed restriction of about 25% during most of the growing period; but because of environmental variations in temperature, the figure may be as low as 15% or as high as 30%.

Controlled feeding important: The purpose of feed restriction during growing is to control the feed intake so that the pullet reaches sexual maturity at a weight appropriate for her strain. Table 36.1 gives an approximation of the results of different levels of feed restriction. Notice that in this test it required a 26% reduction in feed intake to attain the desired weight at maturity.

TABLE 36.1

EFFECT OF RESTRICTED FEEDING ON AGE AND BODY WEIGHT OF MEAT-TYPE PULLETS AT SEXUAL MATURITY

Percent of Full Feeding	Age Laying Began	Avg. Body Weight at First Egg	
	Wk	Lb	Kg
100	19	6.2	2.8
85	22	5.7	2.6
74	24	5.4	2.4
61	27	4.9	2.2

CONTROLLED GROWING FEED PROGRAMS FOR MEAT-TYPE BIRDS

Three feeding programs have become popular for growing meat-type breeder replacement pullets. Each involves identical feed restriction when computed on the basis of *weekly* feed consumption. Each may be varied to increase or decrease the feed consumption as necessitated by growing body weight. The three programs are:

(1) *Limited-every-day feeding program:* The pullets are given feed each day but less than they would eat if allowed full-feed.

(2) *Skip-two-days-per-week feeding program:* The pullets are given feed on 5 days out of every 7, but there must be a measured amount of feed on feed days.

(3) *Skip every-other-day feeding program* Birds are fed every other day, but the amount of feed given on feed days must be regulated

Feed Allocations for Controlled Feeding Programs

The program of controlling the feed intake should begin during the seventh week, but only the *daily* feed intake should be restricted during the seventh, eighth, and ninth weeks (from 43 to 63 days of age) Feed should be given every day At the beginning of the tenth week (64 days), one of the above 3 controlled feeding programs should be initiated Although the amount of feed allocated on feed days will vary with the strain of pullets and with daily environmental temperatures and the body weight of the bird, approximations are given in Tables 36 2 and 36 3

TABLE 36 2

ESTIMATED CONTROLLED FEED ALLOWANCES FOR MEAT TYPE GROWING PULLETS BY WEEKS*
(In Pounds)

Week	Desired Average Flock Weight Lb	Approximate Feed Amounts per 100 *Birds* on Feed Days Controlled Feeding Program					
		Limited Every Day		Skip 2 Days per Week		Skip Every Other Day	
		Lb	Cum	Lb	Cum	Lb	Cum
		Full feed Estimated					
1	0 25	3 5	25	3 5	25	3 5	25
2	0 52	5 1	60	5 1	60	5 1	60
3	0 83	7 3	112	7 3	112	7 3	112
4	1 19	9 1	176	9 1	176	9 1	176
5	1 60	11 2	254	11 2	254	11 2	254
6	2.06	13 6	350	13 6	350	13 6	350
		Controlled Feed Intake Feed Every Day					
7	2.57	13 0	441	13 0	441	13 0	441
8	2.75	13 5	536	13 5	536	13 5	536
9	2.94	13 5	630	13 5	630	13 5	630
		Controlled Feed Recommendations for Three Programs					
10	3 13	14 0	728	19 0	725	27 0	725
11	3 32	14 0	826	19 0	820	27 5	821
12	3 51	14 5	928	19 5	918	28 0	919
13	3 70	15 0	1033	20 5	1020	29 0	1020
14	3 89	15 5	1141	21 5	1128	30 0	1125
15	4 08	16 0	1253	22 5	1240	31 0	1234
16	4 27	16 5	1369	23 0	1355	32 0	1346
17	4 46	17 0	1488	23 5	1473	33 0	1461
18	4 65	17 5	1610	24 0	1593	34 0	1580
19	4 84	18 0	1736	24 5	1715	35 0	1703
20	5 03	18 5	1866	25 0	1840	36 0	1829
21	5 22	19 0	1999	25 5	1968	37 0	1958
22	5 40	19 5	2135	27 0	2103	38 0	2091

*Moderate weather

TABLE 36 3

ESTIMATED CONTROLLED FEED ALLOWANCES FOR MEAT TYPE GROWING PULLETS BY WEEKS*
(In Kilos)

Week	Desired Average Flock Weight Kg	Approximate Feed Amounts per 100 *Birds* on Feed Days Controlled Feeding Program					
		Limited Every Day		Skip 2 Days per Week		Skip Every Other Day	
		Kg	Cum	Kg	Cum	Kg	Cum
		Full feed, Estimated					
1	0 11	1 6	11	1 6	11	1 6	11
2	0 24	2 3	27	2 3	27	2 3	27
3	0 38	3 3	51	3 3	51	3 3	51
4	0 54	4 1	80	4 1	80	4 1	80
5	0 73	5 1	115	5 1	115	5 1	115
6	0 93	6 2	159	6 2	159	6 2	159
		Controlled Feed Intake Feed Every Day					
7	1 17	5 9	200	5 9	200	5 9	200
8	1 25	6 1	243	6 1	243	6 1	243
9	1 33	6 1	286	6 1	286	6 1	286
		Controlled Feed Recommendations *for Three Programs*					
10	1 42	6 4	330	8 6	329	12 2	329
11	1 51	6 4	375	8 6	372	12 5	372
12	1 59	6 6	421	8 8	416	12 7	417
13	1 68	6 8	469	9 3	463	13 2	463
14	1 76	7 0	518	9 8	512	13 6	510
15	1 85	7 3	568	10 2	563	14 1	560
16	1 94	7 5	621	10 4	615	14 5	611
17	2 02	7 7	675	10 7	668	15 0	663
18	2 11	7 9	730	10 9	723	15 4	717
19	2 20	8 2	787	11 1	778	15 9	773
20	2 28	8 4	846	11 3	835	16 3	830
21	2 37	8 6	907	11 6	893	16 8	888
22	2 45	8 8	968	12 3	954	17 2	948

*Moderate weather

Notes on Tables 36.2 and 36 3

(1) The 3 growing feed programs shown call for full feeding of a starter mash for the first 6 weeks Feed should be before the chicks at all times

(2) During the seventh, eighth, and ninth weeks the chicks are to be fed every day, but a limited amount of feed is to be given each day

(3) One of the three feed-control programs is to be used beginning with the tenth week, and feed allocations for feed days are given The figures are guidelines only

(4) Regardless of which feed control program is used after ten weeks of age, the *weekly* feed consumption is practically the same. Furthermore,

the total amount of feed necessary to grow a pullet to maturity is very similar in each program

(5) When stress is evident, the pullets should be returned to full feed until the difficulty subsides

(6) On a feed day, feed 1 lb (454 g) of large-size grit per week per 100 birds on litter Do not feed grit on a "no feed" day When birds are on slats or wire, feed 1 lb (454 g) of grit per 100 birds every six weeks Start grit the seventh week

(7) When skipping feed on two days per week, do not skip on consecutive days

(8) The metabolizable energy (M E) in the growing feed formula should approximate 1318 kcal per lb (2900 kcal per kg) A protein content of about 15% is adequate Because the growing feed is restricted (controlled) it is advisable to practice only a modest amount of phase feeding

Recommendation for phase feeding At seven weeks, use a 16% protein ration, then change to a feed with 14% protein when the birds are 14 weeks of age

(9) The purpose of a controlled growing feed program is to regulate the feed intake so as to maintain optimum body growth If the weather is cold, it will be necessary to increase the feed allocations to maintain satisfactory growth, when it is hot, the feed should be reduced

Caloric Content of the Controlled Growing Diets

Table 36 4 shows the realtionship between kilocalories of M E consumed per day and per pound (kilo) of body weight during the growing period when the pullets are fed one of the controlled feeding programs given in Tables 36 2 and 36 3 Two points are very important to the success of such feed control or restriction

(1) The kilocalories of M E allocated *per pullet* per day *must increase as* she grows older

TABLE 36 4

METABOLIZABLE ENERGY CONSUMED PER MEAT TYPE PULLET AND PER POUND (KILO) OF BODY WEIGHT PER DAY ON CONTROLLED GROWING FEED PROGRAMS

(Moderate Temperature)

Week	Feed per Pullet per Day		Kcal M.E Consumed per Pullet per Day*	Recommended Body Weight		Kcal M E Consumed per Day per Unit of Body Weight	
	Lb	Gm		Lb	Kg	per Pound	per Kilo
8	0 135	61 2	177	2.75	1 25	65	142
10	0 140	63 6	184	3 13	1 42	58	130
12	0 145	65 8	191	3 51	1 59	54	120
14	0 155	70 3	204	3 89	1 76	52	116
16	0 165	74 8	217	4 27	1 94	51	112
18	0 175	79 4	230	4 65	2 11	50	110
20	0 185	83 9	243	5 03	2.28	48	106
22	0 195	88 5	257	5 40	2.45	48	105

*Ration contains 1318 kcal M E. per pound (2900 kcal M E per kilo)

(2) The kilocalories of M.E. per *pound of body weight* must decrease but slightly after 14 weeks of age. As long as the caloric content of the ration or the feed allocations do not vary from the schedule, this rule remains true.

Protein Intake on Controlled Growing Feed Programs

The daily protein consumption for meat-type pullets raised on one of the controlled feeding programs given in Tables 36.2 and 36.3 is as important as the caloric intake. These figures are given in Table 36.5.

TABLE 36.5

PROTEIN CONSUMED PER PULLET AND PER POUND (KILO) OF BODY WEIGHT PER DAY ON CONTROLLED GROWING FEED PROGRAMS*

Week	Grams of Protein Consumed per Pullet per Day	Grams of Protein Consumed per Day per Unit of Body Weight	
		per Pound	per Kilo
8	9.2	3.3	7.3
10	9.5	3.0	6.6
12	9.9	2.8	6.2
14	10.5	2.7	5.9
16	11.2	2.6	5.7
18	11.9	2.6	5.7
20	12.6	2.5	5.5
22	13.3	2.5	5.5

*15% protein growing ration, moderate temperature.

Daily protein consumption per pullet: The figures are calculated on the basis of a growing ration with 15% protein fed throughout the entire growing period. Under these conditions, the protein consumed per day at the end of the growing period is somewhat high, and undoubtedly there is some waste when 12 or 13 gm of protein are consumed per pullet per day.

Daily protein consumption per pound of body weight: As the pullet ages, her intake of protein on a pound of body weight basis decreases, and could be even lower during the last half of the growing period if phase feeding were followed.

Starting Feed Control at Seven Weeks

Although one of the three-mentioned feed control programs should not be initiated until the beginning of the tenth week, some mild reduction in feed consumption is best begun at the start of the seventh week. This makes it easier to change to one of the skip-day programs the tenth week.

Careful the seventh week: Although Tables 36.2 and 36.3 call for a small weekly reduction in feed consumption the seventh week, the amount of this decrease will be determined by the feed consumption the sixth week. Do not cut down the feed intake by more than 0.6 lb (272 gm) per 100 pullets per day. *If the birds are stressed in any way, do not make a feed reduction at this time.*

Growing Feed Reductions Not as Great as They Appear

Table 36 6 shows the relationship between full feeding and restricted feeding Notice that during the eighth week the feed allocation on the restricted program is 10% less than the amount eaten by pullets on full feed The percentage figure increases until it reaches a reduction of 26% the 14th week, after which it remains constant This would seem a drastic reduction, but when comparison is made on the basis of body weight, it is actually small

TABLE 36 6

COMPARISON OF CONTROLLED FEEDING VS FULL FEEDING MEAT TYPE GROWING PULLETS
(Moderate Temperature)

Week of Age	Controlled Feeding: Feed Consumption per 100 Pullets per Day Lb	Controlled Feeding: Desired Body Weight Lb	Full Feeding: Feed Consumption per 100 Pullets per Day Lb	Full Feeding: Approximate Body Weight Lb	Controlled Feed Restriction (Weekly Basis) %
4	9 1	1 19	9 1	1 19	0
6	13 6	2.06	13 6	2 06	0
8	13 5	2.75	14 9	3 05	10
10	14 0	3 13	17 5	3 91	20
12	14 5	3 51	19 1	4 65	24
14	15 5	3 89	20 9	5 30	26
16	16 5	4 27	22 3	5 84	26
18	17 5	4 65	23 7	6 30	26
20	18 5	5 03	25 0	6 80	26
22	19 5	5 40	26 4	7 25	26

Example When the pullet weighs 4 65 lb on the controlled feed program, feed consumption per 100 pullets per day is 17 5 lb (18th week) When a pullet weighs 4 65 lb on the full feed program, feed consumption per 100 pullets per day is 19 1 lb (12th week)

When the comparison is made on this basis, the feed reduction is only 8%

Early and long-continuing feed reduction important To be effective, any controlled feeding program must start when the chicks are young and continue throughout the growing period

FEEDING MEAT TYPE GROWING COCKERELS

In general, growing cockerels to be used later for breeding purposes should receive the same diet as the matching females Since the males are raised with the females in most instances, this is the only practical application Male growth should be restricted or controlled so that the cockerels enter the breeding period well fleshed, but not fat Most prime breeders of meat-type males can supply growth standards for their line Weigh a sample of the cockerels at the same time the pullets are weighed Table 36 7 gives an example of growing male weights when the diet is restricted

TABLE 36.7

APPROXIMATE MEAT-LINE COCKEREL BODY WEIGHTS UNDER A RESTRICTED GROWING FEED PROGRAM

Week of Age	Guidelines for Approximate Cockerel Body Weights			
	Minimum		Maximum	
	Lb	Kg	Lb	Kg
7	2.9	1.3	3.1	1.4
8	3.2	1.5	3.4	1.5
9	3.5	1.6	3.7	1.7
10	3.8	1.7	4.0	1.8
11	4.1	1.8	4.3	1.9
12	4.3	2.0	4.6	2.1
13	4.6	2.1	4.9	2.2
14	4.9	2.2	5.2	2.4
15	5.2	2.4	5.5	2.5
16	5.5	2.5	5.8	2.6
17	5.8	2.6	6.1	2.8
18	6.1	2.8	6.4	2.9
19	6.4	2.9	6.7	3.0
20	6.6	3.0	7.0	3.2
21	6.9	3.1	7.3	3.3
22	7.2	3.3	7.6	3.4

CHANGING EGG-TYPE BREEDERS FROM GROWING TO BREEDING DIET

The program for changing egg-type breeders from the growing to the breeding ration is identical with the program for changing egg-type commercial pullets from a growing to a laying ration. See Chapter 35. Necessarily, a breeder ration capable of producing high hatchability of the eggs laid is to be used rather than a laying ration. Substitute the breeder ration when the flock is about 20 weeks (140 days) of age. This gives ample time for the pullets to build yolk reserves of certain vitamins and other feed components before production of the first hatching eggs.

CHANGING MEAT-TYPE BREEDERS FROM GROWING TO BREEDING DIET

At about the time the meat-type pullet reaches sexual maturity it becomes necessary to change from the growing feed program to the laying feed program. Because of the drastic feed reductions made during the growing period, and the fact that feed intake must be increased greatly when egg production begins, this calls for a detailed program. Furthermore, most meat-type pullets are raised on a skip-day feeding program and when egg production begins, they must be fed every day.

Chronological Order When Changing Feeding Programs

The day-by-day procedures for making the change from the growing feed to the laying feed programs are given in Table 36.8. It is important that these be followed very carefully.

What must be considered: In making the changeover, the following are to be taken into consideration:

(1) Change from the grower to the breeder ration on the 140th day, but continue the *controlled* growing feed program for 2 more weeks (through 154 days)

(2) Start to increase the breeder feed intake on the 155th day, taking one week to get the pullets on full feed Recommended daily feed allotments for this period are given in Table 36 8

(3) Full feed the breeders beginning on the 162nd day

Important change made in feed measure The figures dealing with feed consumption in Tables 36 2 and 36 3 are on the basis of birds only, but the feed allotments given in Table 36 8 are given in pounds and kilos per 100 pullets, *including the male feed* Thus, the figures in Table 36 8 are proportionately higher

TABLE 36 8

GUIDELINES FOR CHANGEOVER FEEDING RECOMMENDATIONS FOR MEAT TYPE BREEDERS
[Feed per 100 Pullets per Day (*Male Feed Included*)]
(Moderate Temperature)

Age of Flock		*Growing Feed Program*								
		Limited Every Day			Skip 2 Days per Week			Skip Every Other Day		
Week	Day	Amount of Feed Fed on Feed Days Lb	Kg	Type of Feed	Amount of Feed Fed on Feed Days Lb	Kg	Type of Feed	Amount of Feed Fed on Feed Days Lb	Kg	Type of Feed
20	140	20 4	9 3	Grower	27 5	12 5	Grower	40 0	18 1	Grower
21	141	21 0	9 5	Breeder	No feed			No feed		
	142	21 0	9 5	"	28 0	12 7	Breeder	41 0	18 6	Breeder
	143	21 0	9 5	"	28 0	12 7	"	No feed		
	144	21 0	9 5	"	No feed			41 0	18 6	"
	145	21 0	9 5	"	28 0	12 7	"	No feed		
	146	21 0	9 5	"	28 0	12 7	"	41 0	18 6	"
	147	21 0	9 5	"	28 0	12 7	"	No feed		
22	148	21 5	9 8	"	No feed			41 8	19 0	"
	149	21 5	9 8	"	29 7	13 5	"	No feed		
	150	21 5	9 8	"	29 7	13 5	"	41 8	19 0	"
	151	21 5	9 8	"	No feed		"	No feed		
	152	21 5	9 8	"	29 7	13 5	"	41 8	19 0	"
	153	21 5	9 8	"	29 7	13 5	"	No feed		
	154	21 5	9 8	"	29 7	13 5	"	41 8	19 0	"
		Amount of Feed Fed Every Day								
23	155	24	10 9	Breeder	24	10 9*	Breeder	24	10 9*	Breeder
	156	26	11 8	"	26	11 8	"	26	11 8	"
	157	28	12.7	"	28	12 7	"	28	12 7	"
	158	30	13 6	"	30	13 6	"	30	13 6	"
	159	32	14 5	"	32	14 5	"	32	14 5	"
	160	34	15 4	"	34	15 4	"	34	15 4	"
	161	36	16 3	"	36	16 3	"	36	16 3	"
24–30**	162 to 210	Full feed breeder feed—all 3 programs								

* Previously this was a "no-feed" day
** Approximate to after peak of egg production

Notes on Table 36.8

(1) The figures given for feed allocations are guidelines only. The amount of feed given at the end of the growing period will have a bearing on the feed allotments in actual practice.

(2) When skip-day growing feed programs have been used, start every-day feeding on a normally "no feed" day nearest a day when the pullets are 155 days of age. To have the birds skip a day of feeding, then follow this with a day of reduced feeding creates too much stress.

(3) The changeover feed amounts are based on the flock attaining 5% hen-day egg production at the end of the 23rd week, certainly no later than the 24th. When the flock is to mature earlier or later, the program should be shifted accordingly.

Chronological Changes in Management Programs

To associate changeover programs involved with feed and light, both are grouped together as follows:

Week of Age	Day of Age	Management Change
20	140	Change from grower to breeder ration but continue controlled feeding.
21	147	Self-feed oystershell.
22	148	Increase the length of light day to 14 hours.
	154	Flock should lay first eggs (1 to 2% production).
23	155	Start feeding controlled amounts of breeder feed every day.
	161	Flock should reach 5% hen-day egg production.
24	162	Full-feed breeder feed every day.
	162	Increase the light day by one hour.
	168	Discontinue free-choice feeding of oystershell.

Problems During the Changeover

It is important that the management changes be made in the order and at the times stated above. To increase feed consumption without increasing the length of the light day, or increase the length of the light day without an increase in feed consumption, can only lead to difficulties; either egg production will be sacrificed or body weight will increase too rapidly during this period.

Hot and cold weather: It must be kept in mind that climatic changes and caloric content of the ration alter the feed consumption. The basic rule is that the bird has need for about 1% more feed with each 1°F drop in temperature and 1% less feed with each 1°F rise; 1% change in caloric content of the ration alters the feed intake by about 0.8%. Referring to Table 36.8, the daily feed consumption the 154th day per 100 pullets (including male feed) is given as 21.5 lb (9.8 kg). Variations at this time because of environmental temperature could be as follows:

Hot Weather		Moderate Weather		Cold Weather	
Lb	Kg	Lb	Kg	Lb	Kg
18.3	8.3	21.5	9.8	24.7	11.2

Caution The guide figures given in Table 36 8 must be corrected for temperature variations However, maintenance of optimum body weight is the index to use in making feed allocations during growing Feed intake must be regulated to maintain the weight, regardless of the temperature

How much feed on the 155th day? The *average daily* feed consumption the week prior to the 155th day (22nd week) will determine the amount of feed to be allocated on the 155th day First make the calculation, then on the 155th day give each 100 pullets 2 5 lb (1 1 kg) more feed (male feed included) than the average daily feed consumption the 22nd week After this, increase the feed allocation 2 lb (0 9 kg) per 100 pullets each day until the flock is on full feed

FEEDING EGG TYPE BREEDERS DURING EGG PRODUCTION

Although the feed formula must be changed during the period of egg production to compensate for the production of eggs that will hatch into quality chicks, the feed management program is identical with that used for the production of commercial eggs by egg type strains See Chapters 33 and 35 In most instances, egg type breeder females are full fed during the laying period If their weight at sexual maturity was correct, their size during the production cycle should be optimum

FEEDING MEAT TYPE BREEDERS DURING EGG PRODUCTION

Until recently, meat type breeder hens were full fed during the laying period However, this program causes birds to gain too much weight during egg production Not only is the weight increase too great, but too much fat is laid down in the liver To alleviate this condition, most of those having meat type breeders follow some plan of feed restriction during the laying period As in restriction during growing, the program must be related to the body weight increase during the production phase

Controlled Feeding Program During Egg Production

As with all chickens, the bird's need for energy to process the other feed constituents governs the daily feed intake And again, environmental temperature, rate of egg production, and a vast array of other factors, affect the daily quantity of calories the hen requires Only averages under conditions of moderate temperatures can be shown, and such a schedule is given, as a *guide* only, in Table 36 9

Notes on Table 36 9

(1) *Feed per dozen eggs* The standard for total egg production during the 40 week laying period is 154 eggs (12 8 doz) When the flock is full fed a dozen eggs would be produced on 8 5 lb (3 9 kg) of feed (108 5 – 12 8), male feed included On the *controlled feeding program* it would require 7 6 lb (3 5 kg) of feed per dozen eggs, male feed included (97 4 – 12 8)

This saving in feed is the most important reason for using some feed restriction during the egg production period of meat type breeders

(2) *Full feed until past the peak of egg production* It is recommended

TABLE 36.9

GUIDE FOR FEED CONSUMPTION WHEN MEAT-TYPE BIRDS ARE FULL-FED AND FEED ALLOCATIONS WHEN CONTROL-FED
(Moderate Weather)

Week of Egg Production	% Hen-day Egg Production*	Feed Consumed per 100 Hens per Day (Males Incl)*				Female Body Weight**	
		Full-fed		Control-fed			
		Lb	Kg	Lb	Kg	Lb	Kg
1	5	36	16.3	Full-fed		5.6	2.5
2	18	39	17.7	"	"	5.8	2.6
3	44	41	18.6	"	"	5.9	2.7
4	68	43	19.5	"	"	6.0	2.8
5	82	43	19.5	"	"	6.1	2.8
6	81	43	19.5	"	"	6.2	2.8
7	80	42	19.1	"	"	6.3	2.9
8	79	41	18.6	41	18.6	6.4	2.9
9	77	41	18.6	40	18.1	6.4	2.9
10	76	41	18.6	40	18.1	6.4	2.9
11	75	41	18.6	39	17.7	6.5	3.0
12	74	40	18.1	39	17.7	6.5	3.0
13	72	40	18.1	38	17.2	6.5	3.0
14	71	40	18.1	38	17.2	6.6	3.0
15	70	40	18.1	37	16.8	6.6	3.0
16	69	39	17.7	37	16.8	6.6	3.0
17	67	39	17.7	36	16.3	6.6	3.0
18	66	39	17.7	36	16.3	6.7	3.0
19	65	39	17.7	35	15.9	6.7	3.0
20	64	39	17.7	35	15.9	6.7	3.0
21	63	39	17.7	34	15.4	6.8	3.1
22	62	39	17.7	34	15.4	6.8	3.1
23	61	38	17.2	33	15.0	6.8	3.1
24	60	38	17.3	33	15.0	6.9	3.1
25	58	38	17.2	32	14.5	6.9	3.1
26	57	38	17.2	32	14.5	6.9	3.1
27	56	38	17.2	31	14.1	6.9	3.1
28	55	38	17.2	31	14.1	7.0	3.2
29	54	38	17.2	30	13.6	7.0	3.2
30	52	38	17.2	30	13.6	7.0	3.2
31	51	38	17.2	30	13.6	7.0	3.2
32	50	38	17.2	30	13.6	7.1	3.2
33	49	37	16.8	30	13.6	7.1	3.2
34	47	37	16.8	29	13.2	7.1	3.2
35	46	37	16.8	29	13.2	7.2	3.3
36	45	36	16.3	29	13.2	7.2	3.3
37	44	36	16.3	29	13.2	7.2	3.3
38	43	35	15.9	29	13.2	7.3	3.3
39	41	35	15.9	29	13.2	7.3	3.3
40	40	34	15.4	29	13.2	7.3	3.3
Total feed consumed per hen (males included)		108.6	49.2	97.4	44.2		
Total feed consumed per hen (no males)		98.6	44.7	88.5	40.1		

* Estimated.
**Approximate when controlled fed.

that the flock be full fed from the onset of egg production until it is well past the peak This is a critical period, the pullets must gain 15% in weight, and reach better than 80% egg production Not only do they require a large number of calories of energy, but their demand for protein is great

(3) *Gain in body weight prior to peak production* Many times certain flocks will gain more than 15% in weight during the first 7 or 8 weeks of egg production When pullets are too heavy at the date of first egg, they may become excessively heavy at the peak of production Generally it is disastrous to try to correct weight during this early period of production by decreasing feed intake

(4) *Body weight at peak of production* The body weight figures in Table 36 9 are optimum when the birds are on a restricted feed intake However, if the pullets are excessively heavy at peak egg production, the weekly optimum feed reductions thereafter must only be proportionate to those given in the table It is a poor policy to restrict the feed intake more in an endeavor to get the body weight reduced to the figures in the table

(5) *Feed involved in constructing the table* In making the calculations, a feed containing 1260 kcal of M E per lb (2772 kcal per kg) was used If the ration contains more energy, less feed would be required, when it contains less energy, more would be necessary The protein content of the feed is 15%

(6) *Feed per dozen eggs produced* It is interesting to study the variations in the amount of feed necessary to produce a dozen eggs as the pullet progresses through her laying period These figures are given in Table 36 10 and are for those hens kept on the controlled feed program Notice that the feed allocated per dozen eggs produced increases as the hen goes through her egg production cycle, but not as rapidly as her rate of egg production decreases

TABLE 36 10

FEED TO PRODUCE A DOZEN EGGS
(Controlled Feeding Program)

Week of Egg Production	Egg Production		Feed Allocation per Dozen Eggs* (Male Feed Included)	
	% Hen day	Dozens per Day per 100 Hens	Lb	Kg
5	82	6 83	6 30	2 86
10	76	6 33	6 32	2.87
15	70	5 83	6 35	2.88
20	64	5 33	6 57	2.98
25	58	4 83	6 62	3 00
30	52	4 33	6 92	3 14
35	46	3 83	7 57	3 43
40	40	3 33	8 71	3 95

*Moderate weather

Energy and Protein Consumption During Laying Period

Being heavier, but producing fewer eggs than Leghorn commercial pullets, the daily energy and protein requirements of meat-type breeders are vastly different At the peak of egg production, the meat-type breeder hen requires about 490 kcal of metabolizable energy and 26 5 gm of protein per day. However, both the energy and protein requirements decrease rapidly as the laying year progresses. An analysis of the energy and protein consumption per hen per day is given in Table 36 11

TABLE 36 11

ENERGY AND PROTEIN REQUIREMENTS OF MEAT TYPE BREEDER HENS
(Moderate Weather)

Week of Egg Production	Feed Allocation per 100 Hens per Day (*Males Incl*) Lb	Kg	Feed Consumed per Hen per Day (*No Males*) Gm	M E Consumed per Hen per Day* (*No Males*) Kcal	Protein Consumed per Hen per Day* (*No Males*) Gm
5	43	19 5	177	491	26 6
10	40	18 1	165	457	24 8
15	37	16 8	153	424	23 0
20	35	15 9	144	399	21 6
25	32	14 5	132	366	19 8
30	30	13 6	124	344	18 6
35	29	13 2	120	333	18 0
40	29	13 2	120	333	18 0

*Feed contains 1260 kcal M E per lb (2772 kcal/kg) and 15% protein

CALCIUM REQUIREMENTS FOR MEAT-TYPE BREEDERS

Meat-type breeder hens consume more feed than Leghorns, but produce fewer eggs Inasmuch as the calcium requirement of the laying bird is related to her egg production, the calcium percentage in the meat-type breeder diet is materially lower. Most Leghorn laying rations contain from 3.00 to 3.50% calcium, while meat-type laying feeds are formulated with between 2.75 and 3 25% calcium. This reduction does not mean, however, that the calcium need is proportionately less. The reduction in the feed is practical because the meat-type bird consumes a much larger amount of feed.

PHASE FEEDING MEAT-TYPE BREEDERS

Because meat-type breeders are best kept on a program of feed restriction during egg production, the necessity for phase feeding is unlikely. Lowering the protein content of rations used during the latter part of the egg production cycle is possible, and perhaps some protein may be saved, but it must be kept in mind that the production period for meat-type birds averages only about 40 weeks, while the period is 52 or more weeks with egg-type birds.

FEEDING MEAT-TYPE BREEDERS DURING HOT AND COLD WEATHER

If meat-type layers are on a controlled feed intake, there is no need to change the caloric content of the diet during periods of hot or cold weather. Normally,

TABLE 36 12

DAILY FEED ALLOCATION EQUIVALENTS BASED ON VARIATIONS IN HOUSE TEMPERATURE AND CALORIC CONTENT OF FEED

Environmental Average Day time House Temperature	Feed Allocated per 100 Hens per Day from GUIDE (Table 36 9)											
	40 Lb			37 Lb			34 Lb			31 Lb		
	Calories M E /Lb			Calories M E /Lb			Calories M E /Lb			Calories M E /Lb		
	1200	1300	1400	1200	1300	1400	1200	1300	1400	1200	1300	1400
Moderate Weather 65°-70°F	43	40	38	39	37	35	36	34	32	33	31	29
Cold Weather 50°-55°F	49	46	43	45	43	40	42	39	37	38	36	34
Hot Weather 85°-95°F	34	32	30	31	30	28	29	27	26	26	25	23

the feed allocations given in the tables should be increased during cold weather and reduced during hot weather rather than to change the energy in the feed However, if the breeder hens are full fed, the calories in the feed should be adjusted to compensate for temperature changes With regulated controlled feeding, the birds will be consuming less energy than they actually need, so changing the ration is of little importance However, when full fed, the amount of energy consumed has a bearing on the grams of protein consumed per bird per day

Variations in temperature and feed energy To show how variations in the house temperature and the kilocalories of metabolizable energy in the ration affect the bird's need for feed, Table 36 12 is presented The figures in the table show how easy it is to overfeed or underfeed when the weather changes This same theory could be used for growing birds

Example When Table 36 12 suggests that 37 lb of feed containing 1300 kcal of M E be fed during *moderate* weather, this amount of feed is equivalent to

(a) 43 lb during cold weather
(b) 30 lb during hot weather
(c) 45 lb of feed containing 1200 kcal of M E during cold weather
(d) Etc

Feeding Broilers and Roasters

In all probability more is known about the nutrition of the broiler than of any other type of chicken. In the clamor for rapid growth and top feed conversion, scientists have spent countless hours in developing feed formulas that will produce rapid and economical gains in the broiler house. In the feeding of growing pullets, layers, and breeders the method of feed administration is a prime function, but in broiler feeding feed formulation is the major consideration.

Broilers Self-fed

Broilers are given all the feed they will eat from one day of age until market time. Usually the feed is mash or crumbles at the start, with pellets the accepted form after the birds are four or five weeks of age. Relatively speaking, the rations are high in both protein and energy; for rapid growth is essential and high-energy formulas are more conducive to economical weight gains.

Available Energy

The primary sources of energy in broiler feeds are the carbohydrates and fats. However, when protein is fed in excess, it too may become a source of energy. To feed protein for energy is uneconomical; the balance between carbohydrates, fats, and protein in the diet must be carefully constructed.

Calories in starting and finishing diets: The energy in a broiler ration is the highest of any of the poultry feeds. Most such diets provide between 1450 and 1550 kcal of metabolizable energy per pound (3190–3410 kcal/kg) of feed. The finisher ration should contain slightly more calories than the starting diet. Usually some fat is added to the formula to provide these high amounts of energy. Typical rations are shown in Table 33.4, Chapter 33.

Tables 20.6 and 20.7, Chapter 20, show the weekly growth and feed conversion for broilers, by sexes. Calculations for the energy consumption as made from these figures are shown in Table 37.1. Of factual interest are:

(1) The daily energy requirement per bird increases as the birds age, mainly because they are larger.
(2) The daily energy requirement per pound of body weight decreases as the birds grow older.
(3) When compared on a weight basis, there is little if any difference between the males and females in the caloric requirement per pound of bird.

Protein in Starting and Finishing Diets

Theoretically, the diet of the broiler should contain about 24% protein during the first 2 weeks and should decrease each week thereafter. However, it is not practical to make so many changes. Most broilers are fed two rations:

(1) Starter, with 23 to 24% protein
(2) Finisher, with 20 to 21% protein

These two rations pretty well equalize the necessary protein requirement during

TABLE 37 1

ENERGY CONSUMED BY GROWING BROILERS PER DAY*

	Males		Females		Straight run	
	Kcal of M E Consumed		Kcal of M E Consumed		Kcal of M E Consumed	
Week	Per Bird per Day	Per Pound of Body Weight per Day	Per Bird per Day	Per Pound of Body Weight per Day	Per Bird per Day	Per pound of Body Weight per Day
2	90	164	83	163	85	162
4	203	135	175	133	190	134
6	329	118	264	112	296	115
8	455	103	344	99	401	101
10	495	82	384	84	434	83

*Starter (0 through 5 wk) 1450 kcal M E. per lb (3190 kcal/kg)
*Finisher (after 5 wk) 1500 kcal M E per lb (3300 kcal/kg)

the starting and growing periods Actually, the protein requirement for straight-run flocks would approximate the following

Week	% Protein in Ration
1	24
2	24
3	23
4	22
5	21
6	20
7	19
8	18
9	17

Protein Consumption by Growing Broilers

When Tables 20 6 and 20 7, Chapter 20, are used as the standard for feed consumption and growth, the protein consumption may be calculated, using a start

TABLE 37 2

PROTEIN CONSUMED BY GROWING BROILERS PER DAY*

	Males		Females		Straight run	
	Grams of Protein Consumed		Grams of Protein Consumed		Grams of Protein Consumed	
Week	Per Bird per Day	Per Pound of Body Weight per Day	Per Bird per Day	Per Pound of Body Weight per Day	Per Bird per Day	Per Pound of Body Weight per Day
2	6.2	11 3	5 9	11 6	6 1	11 5
4	14 3	9 5	12.8	9 7	13 8	9 6
6	19 7	7 0	15 7	6 7	17 7	6 8
8	27 4	6 2	20 9	6 0	24 0	6 1
10	30 0	5 0	23 7	5 2	26 3	5 1

*Starter (0 through 5 wk) 23% protein
*Finisher (after 5 wk) 20% protein

ing ration containing 23% protein and a finishing ration with 20% protein. These figures are given in Table 37.2, and show:

(1) The grams of protein consumed per bird per day increase markedly as the chick ages, the increase being greater for the males than the females each week because of the more rapid growth.

(2) The protein consumed per pound of body weight decreases as the birds age. On a pound and week basis, there is no difference between the sexes.

Protein consumption per pound of weight is vastly different, however, when birds representing the two sexes, and of equal body weight, are compared. Males, growing at a faster rate, require more protein per day, as shown below:

Body Weight Lb	Kg	Grams of Protein Consumed per Day per Pound of Body Weight Males	Females
1	0.45	10.9	9.1
2	0.91	17.7	14.3
3	1.36	22.5	18.2
4	1.81	25.8	21.3
5	2.27	29.2	24.4

BROILER FEED CONVERSION

Feed conversion, or the units of feed necessary to produce a unit of live broiler weight, is of economic importance to the broiler producer. Feed conversion must not be considered *per se*; the cost of producing a pound of live broiler has a greater significance.

First gains are the most economical, and males are better feed converters than females. Usually, the fastest growing birds have the best feed conversion. But many factors influence feed conversion, for the best results are obtained in the healthy flock grown in a favorable environment. Some of the factors having a bearing on feed conversions are:

- type of litter;
- length and intensity of light;
- ventilation;
- ammonia fumes in the poultry house;
- floor space per bird;
- type of equipment;
- stress;
- disease;
- caretaker;
- strain of birds.

DIFFERENT DIETS FOR MALE AND FEMALE BROILERS

In many instances the male and female broilers are raised separately. The males are sold about a week before the females so that the market weight of each sex will be approximately the same. Rearing the sexes separately has led to the thought that each should receive a different ration, to compensate for the more rapid growth of the cockerels; but thus far, few differences of importance have been made in the basic diets. Evidently the relationship between protein and en-

ergy in the ordinary broiler diet is satisfactory for each sex even though the males do eat more, grow more rapidly, and have better feed conversions

FEEDING ROASTERS

When broiler strains are raised to roaster weights, a broiler finisher ration may be fed to maturity However, a less costly ration may be used after either sex reaches 4 5 lb (2 04 kg) in weight These feeds have a slightly higher energy con tent, and the protein content may be reduced to 17 to 18%

Ultrarapid growth is not always advantageous when raising roasters It is more important that the birds deposit large amounts of fat in the tissues Furthermore, when growth is forced at roaster weights, there is likely to be a higher incidence of breast blisters See Chapter 20

Bacteria, Viruses, Protozoa, and Fungi

DISEASE AND OTHER TERMS

active immunity: Immunity produced in the bird either by natural exposure or by vaccination.

acute disease: A disease of short and severe duration.

agglutination test: A test for the presence of antibodies performed by mixing blood or serum and an antigen.

agglutinin: A substance which causes bacteria or blood corpuscles to coalesce or clump together.

antibiotic: A dilute substance produced by microorganisms that has the power to kill other organisms.

antibody: A substance formed in the body as the result of infection or administration of suitable antigens.

antigen: A protein or carbohydrate that produces antibodies when injected into the bird.

antiseptic: A substance applied to animals which reduces microorganisms to a harmless state, either by killing them or preventing their growth.

antiserum: A serum containing antibodies specific to a certain disease.

antitoxin: A specific antibody capable of neutralizing a specific toxin.

aseptic: Free from pathogenic organisms.

ataxia: Uncoordinated muscular movements (as in avian encephalomyelitis).

attenuated: A disease organism that has been weakened to reduce its virulence.

autogenous vaccine: A vaccine prepared from cultures derived from infected birds and used to immunize against further contagion.

avirulent: An organism that is not virulent or pathogenic.

avitaminosis: A disease or malfunction caused by a vitamin deficiency.

bacteria: Microscopic organisms that are composed of a single cell.

bactericide: A substance that kills bacteria, but not necessarily their spores.

bacterin: A suspension of killed or attenuated bacteria which brings about immunity when injected into the chicken (antigen).

bacteriostat: A substance that inhibits the growth of bacteria without killing them.

blood test: See Agglutination Test.

broad-spectrum antibiotic: An antibiotic which inhibits the growth of many kinds of microorganisms (the more numerous the kinds, the wider the spectrum).

carrier: A chicken that shows no evidence of a disease, yet harbors the organism, and is capable of transmitting the disease to others.

catarrhal: Capable of producing an inflammation of the mucous membranes.

chronic disease: One that has a long duration, usually evidenced by morbidity rather than mortality.

coccidiostat: A chemical compound added to the feed or drinking water to combat coccidiosis.

congestion: An overaccumulation of blood in the blood vessels causing excessive blood in the tissues.

contagious disease An infectious disease that is readily transmitted to other birds
culture (noun) A group of microorganisms grown on artificial media in a laboratory
culture (verb) A procedure used to remove organisms from the bird and to isolate them
detergent Usually a soapless, synthetic, water-soluble agent which reduces surface tension and thus emulsifies oils and has cleansing properties
disease An impairment of the normal function of any body organ or part of the bird
disinfectant A substance that kills pathogenic organisms but not necessarily spores and is usually applied to inanimate objects
dropsy An illness characterized by excessive water in the abdominal cavity
edema An excess of fluid in the tissues of the bird
enteritis An intestinal inflammation
erythrocyte A red cell or corpuscle of the blood used for transporting oxygen
estrogens Certain hormones secreted by the ovary that are capable of governing some of the secretions of the oviduct, and certain synthetic compounds having similar properties
fomites Inanimate objects such as clothing, feed bags, etc , that harbor disease producing organisms
germicide Any agent that kills bacteria, especially those that are disease producing
hemorrhage A condition occurring when blood escapes from the circulatory system
hepatitis An inflammation of the liver
histology Study of the body tissues
hormone A substance produced by specialized body cells, which when transported by the blood system, has the power of effecting a change in other body cells
host An animal that supports a parasite or a pathogenic organism
hydrogen ion concentration A value which indicates the acidity or alkalinity of a solution, running from 1 to 13 (exponentially) Seven is neutral, above 7, is alkaline, below 7, is acid Also called pH
immune A bird is said to be immune when it has some degree of resistance to a particular disease
immunity State of being resistant or immune
implant (verb) To deposit beneath the skin of the bird, as when a caponizing pellet is implanted beneath the skin of the neck
infection The invasion of a pathogen into susceptible tissue resulting in disease
infectious disease A disease produced by the invasion of living microscopic organisms
infectious organism An organism that has the capability of producing disease
isolation Keeping poultry in areas separate from other poultry
lesion A variation in the normal appearance of tissue as the result of a pathogen or injury
microscopic Visible with a microscope
morbidity A sickness in a bird or flock caused by disease

mortality: Death of birds in the flock.
necrosis: Death of living tissue usually caused by lack of blood supply.
neoplasm: Tissue which develops abnormally and usually has no physiologic function, such as a tumor.
parasite: An organism that lives in or on another organism, from which it derives its nourishment.
passive immunity: Usually that parental immunity passed from mother to offspring through the egg (by antibodies), or artificially by the administration of an antiserum.
pathogen: An organism capable of causing disease.
pathogenicity: The capability of an organism to produce a disease; a quantitative term.
pH: See hydrogen-ion concentration.
plasma: The clear solution remaining after the corpuscles have been removed from the blood.
polyvalent: An antigen or bacterin containing several strains of an organism or organisms.
protozoa: Minute protoplasmic acellular or unicellular animals with varied morphology and physiology.
renal: Relating to the kidneys.
sanitizer: A preparation capable of reducing the number of bacteria present, sometimes combined with a detergent.
septicemia: Invasion of the bloodstream by pathogenic microorganisms.
serological test: A test performed on blood serum to determine the presence or absence of specific antibodies.
serotype: A particular strain of a microorganism.
serum: The clear fluid remaining after the corpuscles and clotting properties have been removed from the blood.
sterilizer: Any chemical or agency (steam, heat, etc.) which destroys all forms of life (bacteria, mold, viruses, etc.)
stress: Anything which affects the bird's well-being and lowers its resistance to disease.
surfactant: Chemicals which lower the surface tension of the solvents in which they are dissolved, such as detergents.
syndrome: A group of symptoms common to a specific disease.
titer: A value placed on the potency of a biological agent; when applied to the agglutination test, it is the weakest dilution at which clumping of the antigen occurs.
toxin: A poison produced by the metabolic processes of microorganisms.
tranquilizer: A drug that slows the metabolic rate of the bird as exemplified by reduced heart beat, lowered blood pressure, reduced mental awareness, etc.
vaccine: A preparation of microorganisms (killed, living attenuated, or living totally virulent) which when placed in the body of the bird produces or increases immunity to a certain disease.
variant: In microorganisms, one which exemplifies a variation from the original form, often the result of a mutation.
vector: An animal which carries and transmits parasites to poultry, such as the earthworm, which carries the chicken tapeworm.

vermicide A preparation that kills worms in poultry, either within or outside the host

virulence The relative ability of a microorganism to transmit disease, usually a quantitative term

virus An organism, ultramicroscopic in size, that multiplies only in living cells, some of which are capable of causing disease

wetting agent Any substance which, when added to water, reduces surface tension and improves the cleaning action See also detergent, surfactant

MICROORGANISMS AND DISEASE

Microorganisms constitute a large group of living cells that complete their life cycle in their minute state, they do not form conglomerates of cells as are found in the higher forms of life

Most such cells remain in a single form, although they may align themselves with other, similar cells to form long filaments or chains Being living organisms, their function is similar to that of higher organisms They digest and assimilate food, and excrete waste products

As do higher forms of life, they necessarily must fight for survival Being small, they have been provided by nature with a survival potential through their ability to reproduce in extremely large numbers These large numbers mean that dissemination is great, most microorganisms are abundant everywhere

Some microorganisms are necessary to complete various reactions required to sustain the complex forms of life Others are pathogenic, they produce certain reactions that are detrimental to the higher forms, among which is the chicken It is this group that we are interested in

The organisms producing diseases in chickens are too small to be seen with the naked eye, a microscope must be used All such organisms are not similar in structure, size, chemical composition, mode of nutrition, or in the manner in which they attack their host In the main such organisms may be divided into four classes

(1) Bacteria	(3) Protozoa
(2) Viruses	(4) Fungi

Although the organisms within each of the above groups are similar in many respects, most may be identified only by using intricate laboratory techniques

BACTERIA

Disease producing bacteria are abundant in the poultry world These organisms are capable of invading the chicken, where they multiply rapidly through cellular division, and produce a physiological change in the host bird that it cannot withstand Sickness follows, and if the reaction is severe enough mortality may result

Bacteria exist in three forms

(1) spherical or coccus,
(2) rod-shaped (bacterium or bacillus),
(3) spiral (vibrio, spirochete, spirillum)

How Bacteria Grow

Commonly, the bacteria divide by a fission that separates each cell into two equal halves However, cocci may divide in several planes, producing the long

chains or sheets common to their type Some other bacteria split in a Y-form, in others, budding is prevalent

Once the disease-producing bacteria gain entrance to the chicken, multiplication of the cells is rapid One cell divides into 2, 2 into 4, 4 into 8, 8 into 16, etc But geometric multiplication (commonly called exponential growth) does not continue forever, soon there is competition for a food supply and oxygen, and many cells may become incapable of division But the numbers are soon so large that their ability to produce disease in the bird is far beyond the quantity necessary

Organisms grow similarly in the laboratory Bacteria may be made to grow and reproduce in the laboratory by using artificial means The bacteria are removed from the host, or from other laboratory cultures, and placed on or in a medium known to furnish the correct food material and moisture The medium is then warmed to a certain temperature to create optimum growth When the bacteria are placed on a medium such as agar, cell division is rapid and *colonies* of the growing organisms may easily be observed with the naked eye Each organism produces its own pattern of colony of different shape, color, and makeup, and this pattern presents one means of identifying the type of bacteria observed

Variant forms of bacteria Many bacteria, particularly those in certain Salmonella groups (e g , *S pullorum*), have through the years developed variations in their makeup, giving rise to several types of the same organism Some of these variations may be due to mutations, others to differences in the environment in which the bacteria live But these variations have caused many misinterpretations in the reading of agglutination tests and in the production of antibodies Many antigens in use today include one or more of the variant strains of bacteria, in order that the antibodies being produced by the bird being tested will detect carriers of all forms of the *Salmonella pullorum*

How Bacteria Produce a Contagious Disease

Poultry diseases may be classified as *contagious* and *noncontagious* When contagious, they are capable of being transmitted from one bird to another Some bacteria produce the actual condition of the disease, others lower the bird's resistance, thus increasing the possibility of outbreaks of other diseases

In most instances a disease is the result of the entrance of the disease producing bacteria into the bird, and the ensuing multiplication The organisms produce toxins which, in turn, are antagonistic to the host Being quantitative, the greater the amount of the toxin, either by increased cellular production or because the quantity of bacteria is overwhelming, the greater the effect of the disease

Toxins produced by bacteria are of varying sorts

(1) those produced by living organisms (exotoxin, tetanus),
(2) those not liberated from the cell until the cell dies or disintegrates (endotoxin, staphylococcal food poisoning),
(3) those which liberate hemoglobin from the red blood cells,
(4) those which break down barriers that prevent the invasion of disease-producing organisms

The *virulence* (pathogenicity) of an organism is a measure of its ability to produce disease Each organism varies according to its power to invade the tissues,

and in production of the necessary toxins The rate of multiplication of the cells within the host is also a contributing factor

Virulence within a species of bacteria may vary Many disease producing organisms remain in a quiescent state within many birds, but when conditions are right, they take on a new life, multiplying and producing toxins in abundance

On farms where successive groups of chicks are started, the virulence of the organism will be increased in each lot once an outbreak occurs Not only does the disease strike harder, but it attacks the birds at a younger age

Host Must be Susceptible for a Disease to Develop

Conditions must be right, and the host susceptible, for the bacteria to make an invasion and produce the disease Nature has endowed the bird with two protective devices to prevent invasion, and with certain other factors to help reduce incidence of the disease

(1) Those which prevent (or attempt to prevent) organisms from entering the body such as
 (a) secretions,
 (b) skin,
 (c) mucous membrane

 However, these protections are generally minor, invasion through skin abrasions, via the respiratory tract, and by other means (or methods), usually overshadow their benefits

(2) Those which fight the organisms that have entered the body

 Each type of bacteria causes the production of an unassociated chemical that acts to destroy the organism that produced it This self destruction is, in most instances, complete to the extent that all the disease producing bacteria in the body are destroyed, and the disease in the flock subsides See Chapter 39 for complete details

(3) Species resistance

 Certain bacteria may invade hosts other than the chicken These bacteria will grow and multiply but will produce no discomfort or other evidence of the disease Some other bacteria may invade and cause disease symptoms in several hosts Some diseases quite common in the chicken occur in several types of poultry (duck, quail, turkey, etc)

(4) Age susceptibility

 Some diseases attack chickens of a certain age and produce disastrous results, yet show few, if any, symptoms in birds of other ages

(5) Climate and season

 Some poultry diseases affect birds more during cold weather than during warm, others are more prevalent during periods of warm or hot weather

(6) Freedom from stress

 The physiological well being of the individual has an effect on the incidence of disease outbreaks Good nutrition, freedom from stress, adequate housing, and temperature control improve the condition of the bird, making bacterial outbreaks less likely

VIRUSES

A second group of disease-producing organisms is represented by the viruses. They are living organisms, exceptionally small in size. Commonly known as *filterable viruses*, they are capable of passing specific filters which bacteria will not permeate. The common microscope is of no value in detecting these as they are so small, but the electron microscope is capable of photographing them.

Viruses multiply only in cells: Bacteria can multiply almost anywhere in the body, but a virus can live and reproduce only within a cell of the host.

Treatment of viral disease difficult: To attack the living virus it is necessary to get to the seat of infection, namely, the cell. This is most difficult, and for this reason any chemicals or antibiotics administered in the feed or drinking water are seldom effective in treating a viral infection. Sometimes injections are of little value even though they quickly get into the bloodstream.

Properties of the Viruses

Although infinitely small, there is a great variation in the size of viruses, some being 25 times as large as the smallest. They invade the host cells, and it is this invasion that is thought to precipitate the respective disease, rather than any toxin produced.

Disease evidence variable: Viruses are capable of producing diseases of vastly varying characteristics. Some invade the respiratory tract, including the air sacs. They produce such diseases as:

(1) fowl bronchitis;
(2) Newcastle disease.

Others produce tumors in such diseases as:

(1) Marek's disease;
(2) lymphoid leukosis.

Still others are responsible for such diseases as:

(1) fowl pox;
(2) avian encephalomyelitis.

Secondary invaders: When a virus attacks the cells of the lining of the respiratory tract and the air sacs, the cell walls are ruptured and become a point for easy invasion of other viruses and bacteria. In many cases the disease developed by the primary invader virus may produce little damage to the bird, but the secondary invader may cause all kinds of trouble.

How Viruses Multiply

Surprisingly, little is known about the exact life cycle of most viruses. Their small size has confused experimental work. Some think that the virus particles do divide and multiply as do bacterial cells. Yet others feel that a virus is inanimate, and must rely on the cell it invades for its reproduction, using the enzymes from the cell to complete the process. The consensus of this group of workers is that viruses are specific in their need for certain enzymes and seek out a location in the body where they are produced. Thus, some viruses invade tissue, some the bursa of Fabricius, others the respiratory tract, etc.

and in production of the necessary toxins The rate of multiplication of the cells within the host is also a contributing factor

Virulence within a species of bacteria may vary Many disease producing organisms remain in a quiescent state within many birds, but when conditions are right, they take on a new life, multiplying and producing toxins in abundance

On farms where successive groups of chicks are started, the virulence of the organism will be increased in each lot once an outbreak occurs Not only does the disease strike harder, but it attacks the birds at a younger age

Host Must be Susceptible for a Disease to Develop

Conditions must be right, and the host susceptible, for the bacteria to make an invasion and produce the disease Nature has endowed the bird with two protective devices to prevent invasion, and with certain other factors to help reduce incidence of the disease

(1) Those which prevent (or attempt to prevent) organisms from entering the body such as
 (a) secretions,
 (b) skin,
 (c) mucous membrane

 However, these protections are generally minor, invasion through skin abrasions, via the respiratory tract, and by other means (or methods), usually overshadow their benefits

(2) Those which fight the organisms that have entered the body
 Each type of bacteria causes the production of an unassociated chemical that acts to destroy the organism that produced it This self destruction is, in most instances, complete to the extent that all the disease producing bacteria in the body are destroyed, and the disease in the flock subsides See Chapter 39 for complete details

(3) Species resistance
 Certain bacteria may invade hosts other than the chicken These bacteria will grow and multiply but will produce no discomfort or other evidence of the disease Some other bacteria may invade and cause disease symptoms in several hosts Some diseases quite common in the chicken occur in several types of poultry (duck, quail, turkey, etc)

(4) Age susceptibility
 Some diseases attack chickens of a certain age and produce disastrous results, yet show few, if any, symptoms in birds of other ages

(5) Climate and season
 Some poultry diseases affect birds more during cold weather than during warm, others are more prevalent during periods of warm or hot weather

(6) Freedom from stress
 The physiological well being of the individual has an effect on the incidence of disease outbreaks Good nutrition, freedom from stress, adequate housing, and temperature control improve the condition of the bird, making bacterial outbreaks less likely

FUNGI

Fungi are a group of organisms containing the molds and yeasts. Generally they grow outside the chicken, producing toxins. When consumed they may continue to grow, the toxin causing a distinct setback in the bird's well-being. In other cases, continued ingestion of the mold and toxin produces the disease-like effect.

Two important poultry diseases: There are two poultry diseases caused by fungi:

(1) Aspergillosis, caused by the mold, *Aspergillus fumigatus.*
(2) Moniliasis, caused by a yeast, *Monilia albicans.*

Laboratory Propagation of Viruses

Evidence points to the fact that viruses multiply only in living cells, yet all viruses cannot be propagated in this manner in the laboratory Although tissue culture is predominately used for laboratory techniques, other viruses are propagated on the chorioallantoic membrane of the developing chick embryo, some in other ways Plant viruses cannot be propagated on animal tissue

Vaccines The specific virus is used to produce a vaccine against the disease Culture and multiplication of the virus is important in the manufacture of these vaccines, and the medium on which they can be cultivated is quite specific

PROTOZOA

Third in the group of disease producing organisms are the protozoa They are animals and are similar to higher forms of life except for the fact that all the functions are carried out within a single cell In poultry they are parasitic in nature, that is, they live on the contents of the cell, eventually destroying it

Protozoa may have a complex life cycle An example would be coccidiosis in chickens In this case *oocysts* are expelled in the fecal material Heat, oxygen and moisture cause them to sporulate They are then consumed and enter the intestinal tract The cell wall of the sporulated oocyst ruptures, eight infectious organisms exude and soon penetrate the cells of the intestinal lining In turn these grow until the intestinal cells rupture and hemorrhage This is the *asexual* portion of the life cycle, and may be repeated several times, but eventually a *sexual* phase occurs, giving rise to both male and female organisms After other cell invasions, more oocysts are produced and leave the body by way of the fecal material, and the life cycle is complete

Number of oocysts extremely large A teaspoonful of droppings from a bird with severe coccidiosis will contain several million unsporulated oocysts Consumption of as few as 10,000 *sporulated* oocysts will produce evidence of coccidiosis, 200,000 will produce death The invasion is intracellular

Other Protozoal Diseases (Extracellular)

There are other protozoal diseases in chickens The most important ones are

(1) Trichomoniasis Caused by a motile protozoan, which locates in the upper digestive tract (esophagus, crop and proventriculus) The name of the organism is *Trichomonas gallinae*, and its life cycle is different from that of the coccidia

(2) Hexamitiasis Caused by *Hexamita meleagridis*, a motile protozoan, although it seldom affects chickens it is prevalent in quail, ducks, and pheasants

(3) Blackhead This disease is seldom found in the chicken, but is quite common in turkeys It is caused by the protozoan *Histomonas meleagridis* The organism can live but a short while outside the host, however it enters the egg of the cecal worm, and in it can live for a long period Reinfection occurs when the cecal worm eggs are consumed by the chicken

nism establishes itself within the bird, antibody production varies according to

(a) number of organisms involved at invasion time;
(b) virility of the organism;
(c) condition of the bird (freedom from stress);
(d) type of organism.

But for the most part the time required for immunity to develop (through the production of antibodies) is dependent on the organism involved; some need but several hours, others require several days.

Immunity long-lasting: Comparatively speaking, the value of antibodies in protecting the bird against future invasions of the same disease organisms is great and the immunity lasts for a long period. In some instances it continues for a lifetime; in others, for several weeks or months. Immunity is relative, and absolute immunity probably is nonexistent.

Antibodies may not destroy all organisms: In the case of certain diseases, as pullorum disease for example, the *Salmonella pullorum* bacteria in the bird may not be completely destroyed. In this instance, the atrophied ova have no blood supply, which normally would move in antibodies produced elsewhere in the bloodstream. Consequently, any pullorum bacteria harbored in the degenerated tissue of the ova would continue to live on and multiply. But this is not a serious condition, for if any bacteria should happen to be liberated into the bloodstream, their antibodies there would destroy them.

Immunity to Protozoan Organisms

In the case of protozoan infections, such as coccidiosis, immunity is produced in a manner other than through antibodies. Yet the immunity is just as great, and is produced similarly. Even the disease pattern is identical. There is a period of infection, then immunity starts, and finally comes recovery as the result of the production of the immunity. Furthermore, the immunity continues. Although the length of the period of immunity is relatively short, the constant ingestion of sporulated oocysts recreates the immunity, and seemingly it lasts a lifetime.

Fungi Do Not Produce Immunity

The toxins produced by fungi are responsible for certain diseases in poultry, and the longer the toxins are consumed the greater the effects. Neither the fungi nor their toxins are antigenic; no antibodies are formed. The severity and recurrence of the disease is related only to the amount and time of the ingestion of the toxin involved.

Variability in Antibody Production

In the course of a normal outbreak of a disease, antibody production reaches its height, after which it decreases and eventually may be reduced to zero. The rate of this decrease, and the longevity of adequate immunity, is a function of the type of antibody involved. It will vary according to the disease.

Quantitative measure of antibodies present: It is possible to determine the number of antibodies present in the bird. This determination involves computing the *titer*. Titer is really the strength of a solution, or in this

Developing Immunity

Once a bird undergoes infection from a natural means of transmission of a disease producing organism, or from a vaccination, chemicals are produced in the body that tend to kill the organism and endow the bird with *immunity* so that it may withstand future invasions of similar organisms The intricacies of the development of this immunity are varied, and seemingly each organism has its own program

Definition of immunity Immunity is a degree of resistance by the bird to any specific organism In some instances immunity is complete, in others, it is partial

Pattern of a Disease Outbreak

The pattern of most poultry diseases is the same There are three phases

(1) Infection Disease producing microorganisms invade the chicken, and if no immunity is present these organisms attack various parts of the body and produce a sickness in the birds, the type of sickness being specific for the particular disease involved Morbidity is usually rapid, mortality may follow, depending on the severity of the outbreak

(2) Development of resistance Once the microorganisms establish themselves in the host chicken the production of a protective chemical begins, the chemical being specific for the organism involved

(3) Disease subsides Protection develops rapidly and the chemical destroys the causative organisms, in the case of most diseases the outbreak subsides or is reduced to a very low level The bird recovers except for any permanent damage developed during the course of the disease

Antibodies and Immunity

Once a foreign substance enters the chicken, the body acts to eliminate it Some such substances never are assimilated, the body eliminates them through the feces Others, such as some of those generated by the bird, are eliminated through the urinary tract

In essence, bacteria are proteins, composed of one or more protein molecules that are foreign to the bird These foreign protein particles produce a toxic reaction, resulting in what we call disease In trying to eliminate them, the body system generates a chemical that reacts with the organisms or inactivates them This chemical is known as an *antibody* Each antibody is specific for the bacterium or virus that initiated its production As the antibody is especially specific for the protein of the invading organism, the fact that there may be one or more protein molecules involved means that there may be one or more antibodies formed

Independent antibody for each disease The antibody is specific for each type and strain of virus or bacterium that caused its production The antibody produced as the result of one organism will not protect the bird from other organisms, e g , antibodies against infectious bronchitis will have no effect on the Newcastle disease virus

Length of time for antibody production Once the disease-producing orga

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bacteria are passed from the dam to the chick, along with some antibodies. However, the production of antibodies is not great enough in the dam to kill all the bacteria, so some live organisms will be found in the chicks, inducing an outbreak of pullorum.

What may be passed through the egg? There are several possibilities, such as:

(1) No bacteria or viruses, where the dam has neither been vaccinated nor has had the disease.

(2) Live viruses or bacteria, where the dam is in the early stages of a disease or where a live-virus vaccine has been used and antibody production has not yet had a chance to destroy the organisms.

(3) Antibodies, where, from an outbreak of a disease or a vaccination against it, antibodies have been produced in the dam and are transmitted to the chick

Parental Immunity Not Effective With Some Diseases

The antibodies present in the egg yolk find their way to the bloodstream of the chick after the yolk is absorbed into the intestines just before hatching. Normally these antibodies completely protect the young chick against early invasion of most bacteria and viruses. However, in those diseases which involve the respiratory tract, the organisms gain entrance as the bird breathes, thus bypassing the bloodstream and its content of antibodies. An example of this is Newcastle disease. Because the antibodies in the bloodstream cannot destroy the virus of Newcastle in the respiratory tract, early disease outbreaks are prevalent; immunity is overwhelmed.

Length of Parental Immunity

Any parental immunity begins to wane after the chick hatches. Half is lost in three days. By the end of the second week of the chick's life it is minor; it is generally ineffective by the end of the third week, and completely disappears by the end of the fourth. Thus, at best parental immunity can be considered an effective means in preventing disease outbreaks before the chicks are two weeks of age, but even during this period it must be recognized as a highly variable device.

VACCINATION

Immunity is the result of antibody production, and under natural outbreaks of a disease is a normal consequence. But there is also an artificial method of inducing the production of antibodies; this is through a process known as vaccination, using a *vaccine.*

Vaccine Defined

A vaccine is any substance (antigen) used to induce immunity. As used in disease prevention it is a preparation of living, attenuated, or dead microorganisms which, when administered to a bird, will produce or increase immunity to a specific disease.

How Vaccines Work

In most instances vaccines are used to produce a mild infection and a low manifestation of a specific disease. Normally, the formation of antibodies by the use of a vaccine will duplicate that from a natural outbreak, but not always.

case a quantitative determination of the presence of antibodies Titers are usually expressed as a reciprocal of highest dilution of the solution showing *specific activity* Thus, *readings* of 1 16, 1 64, 1 256 would be examples The higher the titer, the greater the number of antibodies

Titer determines resistance Following certain disease outbreaks, when the antibodies slowly decrease, the bird gradually loses its ability to withstand future invasions of the bacterium or virus If the antibodies are reduced to a very low level, reinfection may occur and the bird again may contract the disease The severity of the second invasion will be determined by the number of antibodies in the bird at that time If it is in the medium to low range, the bird may show only slight effects from the disease, but if the quantity of antibodies is low, the disease will be severe The titer or antibody as measured in the laboratory is generally, but not always, the ability to resist infection

Age of the bird and antibodies In respect to many diseases young chicks seem more susceptible than older birds They are immunologically incompetent Usually this is because a greater number of antibodies is necessary to fight the effects of the invading bacteria or viruses As the bird grows older, fewer antibodies will overcome the challenge In some cases, however, as with lymphoid leukosis, older birds show more evidence of the disease than younger ones

Parental Immunity

The protective device for the prevention of many diseases in newly hatched chicks can be attributed to *parental immunity*, sometimes called *passive immunity*

If the breeding hen has had a specific disease, she has produced a large number of antibodies Many of these localize in the ova, and consequently are passed to the chick through the ovum of the hatching egg In turn, these antibodies aid in protecting the chick from invasions of the specific disease producing bacterium or virus when it is quite young But as in the case of the adult mother, these antibodies in the chick wear away and their numbers decrease Furthermore, the decrease of the antibodies is much more rapid in the chick than in the adult bird

Antibody number in chick correlated with number in mother When the amount of antibodies in the hen producing the hatching eggs is high (high titer), the number in the day-old chick is high Usually, the concentration of antibodies in the egg yolk is identical with that in the hen However, there is a decrease by the time the chick is hatched, and the number of antibodies is then about half that in the yolk of the fresh laid egg Thus, to provide ample immunity in the day-old chick, the titer of the mother must be high

Chicks with no parental immunity are easily invaded When the hen producing the hatching egg has not had a specific disease or been vaccinated, she has produced no antibodies against the infection, thus a chick hatched from an egg laid by such a mother would contain no antibodies and would have no protective device to withstand an invasion of the specific bacterium or virus The chick would be completely susceptible

Passing live organisms through the egg Not only are antibodies passed from the dam to the chick through the egg, but live disease producing organisms are similarly transferred One example is pullorum disease, in which viable

paired, and immunity will not reach as high a level as with live or attenuated vaccines.

Another Classification For Newcastle Vaccines

ND virus strains vary in their antigenicity (ability to stimulate antibody production). They are classified according to their virulence (ability) to produce disease. Likewise, ND vaccines are classified, as follows:

(1) *Velogenic vaccine:* A virulent form such as the Boney strain. This strain is used for laboratory work. It will kill 80% of the controls.

(2) *Mesogenic vaccine:* Such vaccines have a medium virulence. The Roakin strain wing-web Newcastle vaccine is an example.

(3) *Lentogenic vaccine:* A vaccine of very low virulence. One using the B_1 strain (Hitchner) is an example. The B_1 type (La Sota) is another, but produces greater immunity than the B_1 strain.

Wing-web Vaccine For Newcastle Disease

Many methods have been employed to find a suitable vaccine for Newcastle disease. The first involves a live-virus, wing-web product. It must be administered by dipping a needle into the vaccine, then pushing the needle through the wing web. Some active organisms enter the bloodstream, and if there has been no previous evidence of Newcastle disease, or parental immunity, they make their way to the respiratory tract where antibodies develop. However, if antibodies are present in the bloodstream, the Newcastle organism is killed and does not reach the respiratory tract, and no additional antibodies are produced. Wing-web vaccine is of no value to birds vaccinated previously with any other form of Newcastle vaccine, because such vaccination produces antibodies which flow in the bloodstream.

Intranasal Vaccines

Certain vaccines may be administered intranasally; that is, they are dropped in one of the nostrils, after which they run into the throat. An alternate method is to drop the vaccine in one of the eyes, after which it slips down the lacrimal duct to the throat. The latter may have the advantage of uniformity of intake, as some chicks exhale the vaccine from the nostril, reducing the amount actually reaching the respiratory tract.

Intranasal vaccines are avirulent and produce only a mild reaction in the bird. One intranasal type is that used against Newcastle disease. By dropping this vaccine into the eye or nostril it goes directly to the respiratory tract. However, there still may be difficulties from parental immunity. The trouble lies in the fact that some antibodies are contained in the cells of the respiratory tract. The greater the parental immunity, the less is the chance that the virus will establish itself and form antibodies. Intranasal vaccination is more effective after the chicks are several days old.

Other Vaccines

There are many other variations in methods of vaccination, each depending on the virility of the vaccine and the manner in which it is administered. These are discussed in Chapter 41, according to the particular disease involved.

The virulence of the vaccine may determine the behavior of a vaccination

(1) *Virulent organisms*
   (a) *Virulent agent by unnatural route* These are virulent agents that take an unnatural route in the body Examples Vent laryngotracheitis and fowl pox at a feathered area
   (b) *When virulent agent is less virulent* Example Wing web Newcastle after four weeks of age
(2) *Low virulence* Examples B_1 Newcastle vaccine, and attenuated as tissue culture Newcastle
(3) *Inactive vaccine* Examples are cholera bacterins and killed Newcastle vaccine

How Vaccines Are Administered

Vaccines may be classified according to the method used to administer them to chickens

(1) intramuscular into the muscle,
(2) subcutaneous under the skin,
(3) ocular in the eye (solution flows through the lacrimal duct to the respiratory tract)
(4) nasal in the nostril,
(5) oral in the mouth,
(6) water into the respiratory tract by way of the throat,
(7) dust into the respiratory tract by way of the nostrils,
(8) bursa of Fabricius into the tissues in the upper portion of the cloaca,
(9) wing web by puncturing the web of the wing,
(10) feather follicle by removing several feathers and swabbing or spraying the vaccine over the area

Types of Vaccines

Vaccines may be classified according to their efficacy or method of manufacture First of all, a vaccine is produced from a live organism specific for a certain disease Each vaccine is the result *of harvesting bacteria or viruses in the laboratory*, then treating them in such a manner that they will not produce their full effects when administered to the chicken This procedure gives rise to the following classification

(1) *Live virus vaccine* The organisms in the vaccine are alive and completely capable of producing the disease in birds not affected or vaccinated previously Containing a live virus, the vaccine is also capable of transmitting the disease to any bird that comes in contact with it
(2) *Attenuated vaccine* By various methods the active organism used to prepare a vaccine may be weakened (attenuated) so that when administered to a bird a milder form of the disease will be produced In many cases there is no evidence of the disease Generally it is impossible for such a vaccine to produce the disease in other birds except through the means employed for vaccination
(3) *Killed vaccine* The organisms used to produce these vaccines have been killed, thus there is no chance they will infect birds They do, however, have the capacity to produce antibodies when used through vaccination In some instances, however, their ability to do this is im

(1) when birds are "off feed";
(2) during periods of extremely hot weather;
(3) when birds have some other disease, such as coccidiosis, etc.;
(4) when birds are to be moved before they recover from a vaccination;
(5) when birds are in a stage of recovery from another vaccination or have recently been moved;
(6) when birds are being medicated or are diseased.

Contaminated Vaccines

It was not long ago that many vaccines on the market were contaminated with impurities, particularly other organisms. As many vaccines are prepared from material harvested from growing embryos, there was always the chance that other organisms growing on the embryos would find their way into the commercial vaccines. With modern techniques however, this possibility is becoming very remote.

Purchase vaccines from a reliable company that will stand behind its products and supply the service necessary to accomplish the best of vaccination. In some countries all vaccines must be COFAL-negative and Mycoplasma-negative.

Vaccination Failure

In spite of all the perfection in vaccine manufacture and the explicit directions for the use of vaccines, there are many failures. In all probability most of these can be traced to the handling and administration of the product. Some rules to follow are:

(1) Keep vaccines under refrigeration.
(2) Keep frozen vaccines frozen.
(3) Do not open the vials of vaccine until you are ready to use them.
(4) Mix vaccines thoroughly.
(5) Do not vaccinate more birds from a vial than the directions recommend.
(6) Keep a record of the vaccine manufacture and the serial number of the vaccine.
(7) Follow the manufacturer's procedures for vaccination.
(8) Do not rush the vaccination job.
(9) When using water-type vaccines be sure there are no sanitizers in the water.
(10) Certain vaccines may be mixed (e.g., bronchitis and Newcastle). With certain others, the vaccinations may be given at the same time, but each a separate operation.

Test For Antibody Production

Just to administer a vaccine is not enough. The vaccine must produce the effect of disease, and antibodies must be established in quantity. In the case of many diseases titers should be established after vaccination to determine if antibody production is adequate. These are laboratory procedures, but they give an accurate picture of the immunity present in the birds. When titers are not high enough to indicate adequate immunity, the birds should be vaccinated again. Then follow this with another reading of the titer.

Parental Immunity and Vaccination

The function of parental immunity is to prevent pathogenic (and other) organisms from producing the effects of disease in young chicks when the incidence of disease might overwhelm their ability to survive But with the advent of vaccines, parental immunity causes a complicating effect on the ability of the microorganisms in the vaccines to establish themselves in the body

It is evident from past experimental work that in most cases it is useless to vaccinate chickens until most of the parental immunity has worn off, which means not before the birds are 14 days of age and preferably, not until they are 21 days of age Although some vaccines might "take" prior to this time if the mother had not passed antibodies (had not had the disease or had been vaccinated), the chances are pretty remote in this day and age that any of the conditions could be a consistent fact There is just too much vaccination of birds to gamble that this could be an actuality

Revaccination

Unless there is some circumstance preventing full results of vaccination, the first vaccination should suffice to build a high quantity of antibodies to the specific disease However, the number of antibodies is at its highest level shortly after vaccination, they gradually wear away, and eventually are reduced to a low level

Variability in parental immunity Because of the reduction in antibodies after vaccinating the mother, parental immunity in the chicks produced from a vaccinated flock is highly variable The longer the time since the vaccination of the mother, the lower the parental immunity If hatching eggs are coming from several flocks of breeders, each in a different period of egg production, some chicks would have a high parental immunity, others, very low

Revaccination of breeders to keep a high titer In the case of those diseases where antibody population deteriorates during the course of a year of egg production, thus involving the degree of parental immunity in the chicks, breeder birds should be revaccinated to reestablish the high titer and the parental immunity in the chicks This procedure is of no value to the breeding hens, as they have ample immunity from one or two vaccinations during the growing period to withstand another disease challenge, but it does maintain uniformity of immunity in newly hatched chicks Not only is the latter of value to the chicks but it makes any program of vaccinating young chicks more uniform, and this is its prime purpose

Anamnestic reaction This refers to memory One can have a bird without a high titer that will have an immediate response to vaccination or infection

Stress and Vaccination

Most present-day vaccines produce a mild effect on the normal, healthy bird However stress can accentuate the effect, producing a greater physiological change in the bird, sometimes with disastrous results

What are the stresses? There are many periods of stress during which birds should not be vaccinated

with certain diseases also have anticoccidial properties of some degree. Drugs in this classification are always given in the feed or water and never injected.

Variations in Drugs and Antibiotics

The preparations used to treat birds have varying properties, making some of them unacceptable for administration in the drinking water or for injections. Others should not be fed.

(1) *Some form solutions:* These are especially well suited for use in the drinking water. They may also be used as an additive to the feed. Usually the water-soluble forms are more expensive than the insoluble forms used as feed additives.

(2) *Some form suspensions:* Drugs used for water application must have the ability to mix uniformly. When the drug goes into solution the mix is uniform. However, soluble forms of some drugs are not available. Some drugs go into suspension, that is, they do not dissolve but float in the water and do not settle out. These also may be used in drinking water.

(3) *Some do not form solutions or suspensions:* These, for the most part, are the insoluble drugs, and their use is confined to administration in the feed.

(4) *Some do not pass from the intestines to the bloodstream:* This property may or may not be an advantage. If the microorganism involved is one that localizes in the intestinal tract, it is advantageous that the drug not be absorbed, but remain in the intestines to act on the organism. However, if the drug must reach the bloodstream to be effective, its ability to pass the intestinal wall becomes important.

Drug Classification According to Use

Examples of the drugs and antibiotics used for disease control are shown below. The list is not complete, as some drugs are available in small quantities in many countries, yet have not been approved for general use in the United States. Some others are in the experimental stage. Many products are sold under other trade names in various countries.

Salmonella-specific:
- antibiotics
- furazolidone (nf-180®)
- sulfonamides

Sulfonamides:
- sulfachlorpyrazine (Esb₃®)
- sulfadimethoxine (Agribon®)
- sulfathiazole
- sulfamethazine (Sulmet®)
- sulfaquinoxaline (S.Q.®)

Furans
- furazolidone (nf-180®, Furox)
- nihydrazone (Nidrafur®, Zonifur)
- nitrofurazone (nfz® Mix, Amifur®)

Drugs and Antibiotics Used in Disease Control

Although vaccination offers a method of preventing many poultry diseases from establishing themselves, certain drugs and antibiotics are used abundantly in the poultry industry to help alleviate the symptoms of a vast number of diseases that gain entrance to flocks The drugs make up an unassociated list of chemicals, and a great many are specific for a certain disease or for a group of similar diseases New ones come on the market regularly, many others are in the process of experimentation Besides the drugs there are the antibiotics They are of general use for three reasons

(1) to aid in promoting growth and better feed conversion,
(2) to help restore the diseased bird to normalcy,
(3) to help prevent certain diseases from becoming established in the bird

It is the latter two which are discussed in this chapter

How Drugs Are Administered

Drugs must reach the pathogenic microscopic organisms in the bird to be effective Most drugs kill on contact, weaken the organism, or upset its life cycle Drugs may be administered as follows

(1) through the feed,
(2) through the drinking water,
(3) through injections into the body of the bird

Classification of Drugs and Antibiotics

Most drugs and antibiotics used for disease control may be classified under the following headings

(1) *Salmonella specific* Although these drugs may have a use in other diseases, generally they are specific for the Salmonella infections, e g, pullorum, typhoid, paratyphoid, etc
(2) *Sulfonamides* Most drugs in this group produce some degree of toxicity, thus they must be used in prescribed dosages Some suppress egg production when used at high levels Scientists are ever on the lookout for new drugs in this category that are less toxic yet produce the necessary results Some have been found
(3) *Antibiotics* Many antibiotics are used in poultry disease control Some are quite specific in relation to the diseases for which they may be used Most are given in the feed or water, but some may be injected

Caution The U.S Food and Drug Administration has withdrawn several antibiotics from the list of those permissible for injection Poultrymen should check with the FDA before using any antibiotic as an injection Streptomycin and dihydrostreptomycin products must be given a 30-day withdrawal period, others may not be used at all

(4) *Coccidial specific* In this group are the coccidiostats However, some also are effective against poultry diseases other than coccidiosis Furthermore, some drugs from other groups used to treat birds afflicted

sulfanitran, butynorate, dinsed, and roxarsone	(Polystat®)
sulfaquinoxaline	(S.Q.®)
sulfonamides	
zoalene	(Zoamix®)
Pasteurella-specific	
racephenicol	(SW-5063)

How Drugs Work

Most drugs are chemicals that disrupt the life cycle of the organism involved. Some cause death; others only inhibit their growth or reproductive powers. As most of the drugs are quantitative, their activity is determined by the amount administered to the bird. Some are effective when given in a large amount over a short period; others are better given in small daily dosages over a long period. To be effective, the manufacturer's recommended dosage must be used. Any dilution will not produce the results anticipated. Some drugs produce excellent results from a disease-prevention standpoint, but also have deleterious effects on the bird. Therefore, care should be taken not to administer more than the recommended amount of any drug.

How Antibiotics Work

Antibiotics are used for disease control. Usually they are specific for those diseases caused by bacteria or related organisms. They are of little value against virus infections. The beneficial effects of antibiotics are due to their ability to disrupt various phases of cellular metabolism.

An antibiotic will prevent multiplication provided enough is present to attack all the bacteria present. If the amount of antibiotic is small and the number of bacteria large, the antibiotic will not produce its full effect. Antibiotics also act by changing the intestinal flora.

Most antibiotics are given in the feed. In some instances, however, they are added to the water so that they may reach the digestive tract faster, for some birds will not eat during the course of a severe disease outbreak, but will drink. In other cases, certain antibiotics may be injected.

Resistance to Antibiotics

When antibiotics are administered to a bird over a long period of time, particularly at a low level, certain species of bacteria become resistant, and finally the resistance becomes so great that the antibiotic is ineffective. In most instances resistance develops only to those antibiotics that are absorbed from the intestinal tract. One antibiotic which is not absorbed is bacitracin. Therefore, bacteria causing a systemic infection will not become resistant to bacitracin.

Potency of Drug Treatment

For any drug to be effective, it must locate at the point of infection in a concentration high enough to combat the invasion of the microorganisms. The amount of the drug in the blood serum is one indication of concentration; another is the quantity in the urine; another is the amount in the intestinal contents.

Drugs differ in their ability to impart concentrations in the blood, urine, intes-

Antibiotic classification Antibiotics may be classified as broad-spectrum, intermediate-spectrum, or narrow-spectrum Examples are

(1) *Broad spectrum* Certain antibiotics (chlortetracycline and oxytetracycline) are effective against a large group of Gram negative and Gram positive bacteria, as
- salmonellae
- staphylococci
- streptococci
- pasteurellae
- coliforms
- PPLO

(2) *Intermediate spectrum*, such as streptomycin and novobiocin

(3) *Narrow spectrum* Includes penicillin, bacitracin, erythromycin and tylosin, which are effective against Gram positive organisms only
- staphylococci
- streptococci
- PPLO

Antibiotics	
bacitracin	
chlortetracycline	(Aureomycin®)
dihydrostreptomycin	
erythromycin	(Gallimycin)
gentamicin	
neomycin	(Neomycin Sulphate 325)
novobiocin	(Albamix)
nystatin	(Myco 20)
oxytetracycline	(Terramycin)
penicillin	(Penicillin, Micro Pen®, Pro Pen "50%")
streptomycin	
tylosin	(Tylan®)
Coccidial specific	
amprolium	(Amprol®)
amprolium plus ethopabate	(Amprol Plus®)
amprolium plus ethopabate	(Amprol Hi E)
bithionol methiotriazimine	(Trithiadol®)
buquinolate	(Bonaid®)
clopidol	(Coyden®)
decoquinate	(Deccox®)
monensin sodium	(Coban®)
nequinate	(Statyl®)
nicarbazin	(Nicarb® "25%")
nihydrazone	(Nidrafur®, Zonifur)
nitrofurazone and furazolidone	(bifuran)
nitromide, sulfanitran and roxarsone	(Unistat®)
sulfachloropyrazine	(Esb$_3$®)
sulfadimethoxine	(Agribon®) (Rofenaid®)

the level in the meat and eggs is negligible. Many governmental regulatory agencies require a *withdrawal period* for some drugs, but not all. This requirement specifies that the drug in question may not be administered for a period of several days before the birds are slaughtered. The period may vary from 3 to 30 days, depending on the drug.

Antibiotic potentiation. Certain antibiotics are used to treat diseases localizing in the intestinal tract. In these cases the antibiotic is administered in the feed or the drinking water only, and soon reaches the portion of the digestive tract affected by the disease. The amount in the tract is identical with that consumed; there is no loss. However, many diseases are systemic, and for the antibiotic to be effective it must leave the digestive tract, be taken into the bloodstream, and be transported to the point of infection. During this process some of the capabilities of the antibiotic are lost. To prevent most of this loss certain antibiotics are given by injection. The loss of the antibiotic when given orally is not the same for all antibiotics, the variation probably being due to the fact that all are not equally absorbed from the intestinal tract.

Oxytetracycline (Terramycin) and chlortetracycline (Aureomycin) are examples of two commonly used antibiotics that show this difference. They are of equal importance in treating intestinal disorders, but more than twice as much chlortetracycline is absorbed from the intestinal tract as oxytetracycline. In order to get the same amount of the antibiotic into the blood, more than twice as much oxytetracycline as chlortetracycline must be fed.

Increasing activity of an antibiotic. Calcium from the feed forms an insoluble salt when combined with oxytetracycline and chlortetracycline in the intestinal tract. This salt is insoluble and cannot be absorbed into the bloodstream. If the calcium in the ration is reduced, the absorption is increased, as a smaller quantity of insoluble salts is produced. The amount of each antibiotic absorbed may be increased more than twofold by deleting the "added calcium" from the ration.

Terephthalic acid and potentiation. This drug (TPA) produces its effect by reducing elimination of the antibiotic in the urine. It increases the response to chlortetracycline four times, and two times to oxytetracycline.

Caution. The use of terephthalic acid is illegal in some countries.

Potentiation cumulative. Potentiation from reducing the calcium in the feed and from TPA is additive, thus the value of chlortetracycline may be increased eight times when both methods of potentiation are used together. The cost of feeding these antibiotics is materially reduced, and it is possible to use high potentiated levels economically.

How to potentiate a feed. There are three methods:

(1) Remove the added calcium from the formula. This method is not always the most practical because the feed will be low in calcium. It should not be fed to young chicks for over five days. A rachitic condition may develop if fed longer.

(2) Remove the added calcium from the formula and replace it with 30 lb (13.6 kg) of sodium sulfate per ton (2,000 lb) of feed. The

tinal contents, and body fluids The dosages recommended by the manufacturer have been worked out carefully, to obtain body concentrations that will be adequate to reduce the infection in the bird These recommendations should be followed carefully

Once a dose of a drug is administered, the *concentration in the body* soon reaches a maximum level This maximum will be reached in the blood in three or four hours Then the elimination of the drug begins and concentration drops off rapidly In many instances the drug is depleted in 24 hours If the drug is effective only at maximum concentrations, the period during which it will affect microorganisms is short To administer less of the drug than the recommended amount will result in body concentrations under those required to effect a kill, to over administer is costly, and of little value

Overdoses sometimes detrimental With certain drugs an overdose may produce detrimental effects in the bird These effects are twofold

(1) *Injurious to the bird* They may cause a toxic reaction or otherwise affect some physiological function of the bird

(2) *Form residues in the tissues* Some drugs are not broken down during the processes of digestion and metabolism and are not eliminated, and as some drugs are toxic or poisonous, their accumulation in the tissues gradually produces a more drastic reaction

Drug retention and humans Those drugs that are not altered during the process of digestion and metabolism and are not expelled from the body of the chicken in the feces and urine after a chemical breakdown soon accumulate to such an extent that they may be potentially injurious to human beings when the poultry meat or the eggs are eaten

In many countries governments have established levels of tolerance of the drugs in the tissues or eggs Above these levels the safety of the meat or eggs for human food is questioned, and in many instances the government may condemn the produce as unfit for human consumption and destroy it Drug manufacturers are aware of this problem, and write their directions for administration very carefully

Tolerance levels and administration levels Because certain drugs may be retained in the tissues and accumulate to a detrimental level, feed regulatory agencies have set up standards showing the amount of each drug that may be used for all methods of administration (feed, water, injection, etc) Feed manufacturers must abide by these directives, and in most instances, must furnish a tag with the feed to show the name and amount of the drug added

Combinations of some drugs cumulative Some drugs similar in chemical makeup supplement the retention potential of other drugs As a consequence, regulatory agencies will allow only certain drugs to be fed simultaneously, others may not be fed at the same time

Drug withdrawal period Some drugs when fed to chickens do not accumulate in the tissues and eggs, but they do affect human beings eating the meat or eggs In most instances these drugs produce their effects in poultry only when administered at high levels Once the administration has stopped, the drugs are soon eliminated from the body of the bird, and

At high levels do not feed continuously to young chicks for more than five days

Erythromycin (Gallimycin)
Form Feed, water, injectible
Intestinal absorption, low

Gentamicin
Form Injectible

Neomycin
Form Feed, water, injectible (injectible produces diarrhea at levels greater than 5 mg per lb of body weight)
Intestinal absorption, none

Oxytetracycline (Terramycin)
Form Feed, water, injectible
When injected, may cause skin irritation
Do not feed to laying hens at levels higher than 200 gm per ton (2,000 lb)
In feed of low calcium content do not feed for more than five days
Slightly anticoccidial
Intestinal absorption, low to medium

Penicillin
Form Feed, water, injectible
Generally used as an injection
Intestinal absorption, low

Streptomycin
Form Feed, water, injectible
Large injections somewhat toxic, birds go to sleep
Intestinal absorption, none

Tylosin (Tylan)
Form Feed, water, injectible
Intestinal absorption, low

Furans

Furazolidone (nf-180, Furox)
Form Feed
Insoluble in water
High levels slightly toxic
Intestinal absorption, good Excreted rapidly through the kidneys

Nihydrazone (Nidrafur, Zonifur)
Form Feed
Do not feed to chickens after 14 weeks

Sulfonamides

Sulfachloropyrazine (Esb_3)
Form Water
Anticoccidial
Very slightly toxic

Sulfadimethoxine (Agribon, Rofenaid)
Form Feed, water
Slightly toxic
At ordinary levels does not seem to depress egg production

sodium sulfate removes the soluble calcium from the intestinal tract by forming calcium sulfate rather than uniting with the oxytetracycline

(3) Add TPA at the rate of 0 4% [8 lb (3 6 kg) per ton (2,000 lb) of feed]

Length of drug treatment To be effective any drug must remain at a high concentration in the body from 3 to 5 days This is difficult, as the period of maximum concentration is of very short duration after a single administration of the drug Administration in the feed or water on a continuing basis is the only acceptable method, but this may prove costly. Low level feeding of a drug to alleviate the disease condition usually is of little benefit Second administrations of some drugs and antibiotics usually are less effective than the first The drugs are eliminated in the urine much more rapidly after the second administration than after the first

Injecting a drug or an antibiotic produces only temporary effects Although the activity reaches a high level quickly, it dissipates more rapidly. Continuous injections every day or two require too much labor and are uneconomical Some drugs and antibiotics used for injection are dissolved in water These are absorbed very rapidly by the system, but their effective duration is short To improve this method some drugs are added to oil, glycol, or wax These are absorbed more slowly, and their duration is longer

Antibiotic Sensitivity Test

Some antibiotics used in the poultry industry produce major effects in treating specific diseases, others are less valuable, and some are ineffective In some instances the birds have become resistant to the antibiotic, producing a change in the value of the drug The laboratory employs a technique known as a *sensitivity test* to determine which antibiotics will be effective in treating a disease. The organisms are cultured and grown on media in which various antibiotics have been incorporated at prescribed concentrations If an antibiotic is to be effective in treating a disease the antibiotic in the medium will prevent reproduction of the organisms The test actually shows which antibiotics will be ineffective, other antibiotics may be of help

FACTORS INFLUENCING USE OF DRUGS AND ANTIBIOTICS

Antibiotics

Bacitracin

Form Feed and water
Intestinal absorption, none
Used primarily during periods of stress and for necrotic enteritis

Chlortetracycline (Aureomycin)

Form Feed and water
Never used for an injection
May be potentiated
Intestinal absorption, medium
Slightly anticoccidial
Levels over 100 grams per ton (2,000 lb) are not to be fed to laying chickens

Poultry Diseases

There are many poultry diseases, but only the most important will be discussed in this chapter. As this is a text on poultry management, the disease section will be aimed at recommendations and directions for the prevention and treatment of each disease discussed. The material involving the cause, symptoms, transmission, and diagnosis has been reduced to include only that information necessary to review the important facts. Detailed discussions can be found in many good textbooks on the subject.

PULLORUM

Pullorum, or pullorum disease, is due to one of the Salmonella organisms. Salmonellae make up one of the largest groups of disease-producing organisms, and over 1,000 have been identified. Some 100 infect birds, but only a few are important to the poultryman, one being *Salmonella pullorum*.

Salmonellae are bacteria that are Gram-negative, are long, slender rods, and have cells usually occurring singly. Although most Salmonellae are motile, *S. pullorum* is not.

Other Names

- White diarrhea
- Bacillary white diarrhea
- BWD

Cause

Pullorum is a highly contagious disease, the organisms localizing in the ovary, liver, heart, testes, and other body organs. Although some bacteria are sluffed through the intestinal tract, it is not the seat of multiplication.

The disease is widespread, and unless precautionary measures are provided to control it, mortality will be high.

Diseases Confused With Pullorum

- Avian encephalomyelitis
- Aspergillosis
- Typhoid
- Paratyphoid

The above diseases affect young chicks; consequently any disease causing mortality during the first four weeks is likely to be confused with pullorum disease.

Symptoms

Pullorum occurs in the chicken, turkey, pheasant, quail, pigeon, and some wild birds. In chickens the age of the bird influences the symptoms; young chicks are affected differently from older birds.

External symptoms: Chicks huddle together, and seem chilled. There is an acute, whitish diarrhea. Vent pasting is prevalent. The appetite drops, feathers are ruffled, and the chicks breathe with difficulty. Hock joints

Sulfamethazine (Sulmet)
- Form Feed, water
- Somewhat toxic at high levels
- On a weight basis only one fourth as effective as sulfaquinoxaline
- Long withdrawal period
- Depresses egg production slightly

Sulfathiazole
- Form Feed, water, injectible
- Slightly toxic

Sulfaquinoxaline (S Q)
- Form Feed, water
- Highly toxic in high concentrations It is an anti Vitamin K drug
- Should not be injected
- Affects egg production at levels over 0 0125% in feed
- Generally should not be administered for over three to five days
- Intestinal absorption, good
- Retained in the tissues for several days
- Do not feed to hens producing eggs for human consumption
- Previous experience *If young chicks have been fed low levels of S Q* , older birds can tolerate higher levels

Another method may be used in passing judgment on whether the bird has, or has not, had the disease This is a test for antibodies It is not to be confused with the laboratory test for the presence or absence of active bacteria

Testing For Antibodies

Once a bird has been infected with the *S pullorum* organism, antibodies specific for *S pullorum* bacteria make their appearance in the bloodstream These specific antibodies clump with the *S pullorum* bacterial cells, inactivating them A similar artificial reaction is used outside the body through a procedure known as the agglutination test This test is widely used to identify layers which have had the disease, but recovered, and are carrying antibodies in their blood

What is needed for the test Among the items needed to complete the test are

(1) whole blood or blood serum,
(2) an antigen, a specially prepared and standardized mixture of killed *S pullorum* bacterial cells, dyes, solvents, etc It is sold by many manufacturers

Two types of tests are in use, the preference being determined by the owner of the birds, or, in many cases, by state or governmental regulatory bodies who establish requirements for the blood test in their region These two tests are

(1) *Rapid, whole blood test* A measured drop (0 5 ml) of antigen is placed on the testing plate Next, the median vein on the underside of the wing near the "elbow" is punctured and a drop of blood (about 0 2 ml) picked up by a loop of wire and the blood mixed with the antigen The plate is rotated in a circular motion to facilitate mixing and clumping If the blood taken from the bird contains *S pullorum* antibodies they will clump with the bacterial cells of the antigen, such a bird is known as a *reactor* If no antibodies are present in the blood, the mixture remains clear, and the bird is known as a *nonreactor*, or is *negative* to the test

Whole blood antigen Most pullorum antigens in use today are of the *polyvalent type*, that is, they contain both the standard and variant strains of bacteria They also may contain killed bacteria of *S gallinarum* strains, along with other Salmonellae Some antigens are known as "K" type, they contain colloidal sulfur as an aid in producing a better reading

Testing the antigen When antigens deteriorate they do not give an accurate reading Freezing, heating, prolonged storage, and other factors reduce their suitability for completing the whole blood test All antigens should be tested prior to any blood tests Secure vials of negative and positive sera Complete the test, using a drop of each test serum instead of blood from the chicken The reaction on the plate (clumping) to the positive serum should be rapid and defined If not, the antigen should be destroyed, and a new supply tested

(2) *Tube agglutination test* A large sample of blood is collected from the bird either by (a) slitting the median vein under the wing or, (b) with drawing the blood from the vein with a hypodermic syringe The

may become inflamed If the infection comes through the hatching eggs, the disease has an early onset, death losses may begin as early as the second day If other chicks are the source of infection, most losses occur after one week of age Death in most affected birds is rapid Losses may run as high as 50%

In older growing birds, and those in egg production, there are few, if any, external symptoms except for a greenish brown diarrhea Fertility and hatchability of the eggs laid by breeder hens may be affected

Internal symptoms An acute septicemia may be involved, and blood infection is the cause of death in young chicks However, a visual examination of the internal organs may show few changes from the normal, except for the highly mucous contents of the intestines, and unabsorbed yolk on occasion

In adult birds the internal symptoms may or may not be observable Localism of the organisms in the ovary sometimes causes some of the ova to atrophy The sex organs of the male may be affected Sometimes the heart and gallbladder show indications of a definite infection by the presence of grayish nodules, but generally a diagnosis cannot accurately be made from a visual observation

Transmission

Transmission is possible from bird to bird There are several avenues

(1) *Through the droppings* Young chicks with the disease continue to sluff *S pullorum* organisms through the fecal material, and this represents the major means of transmission However, in adult birds the fecal material contains few *S pullorum* and is not a major means of spread

(2) *Cannibalism* This is an important means of transmission

(3) *Birds eating eggs* Many of the *S pullorum* bacteria localize in the ovary, and many of the ova may become infected Some of the infected ones are ovulated If a chicken eats a newly laid, infected egg, the organisms gain entrance to the bird

(4) *Equipment* Contaminated equipment may be the source of infection Debeakers offer a means of transferring the bacteria from bird to bird

Transmission through the egg The most important route of transmission of infection is from the infected dam, through the hatching eggs, to the newly hatched chick Although all ova from an infected layer are not involved, enough are infected to carry the causative organisms to the next generation A few infected chicks will soon transmit *S pullorum* bacteria to most chicks in the incubator (hatcher) or in the pen

Important The hatcher section of the incubator is the seat of high contamination Organisms from hatch debris—shells, down, and droppings—are easily blown throughout the cabinet by the electric ventilating fans

Diagnosis

The *Salmonella pullorum* organism is easily isolated and identified in the laboratory Cultures taken from such organs as the ovary, testicles, heart, liver, and spleen are used to make the laboratory determinations

infected, antibodies begin to appear about a week later These antibodies increase in number until they reach a maximum in about three weeks During this three week period there may not be an adequate number of antibodies present in the blood of the bird to cause a reaction to either of the agglutination tests

Should All Breeder Flocks be Blood-Tested?

As a general rule, all breeder flocks should be blood tested for pullorum disease However, the integrator, who uses his own chicks in his production program, may find it economically advantageous to dispense with the program As all prime breeders blood test, the integrator is assured that his breeder chicks at least start their life free of the disease Under modern poultry sanitation programs, there is little chance that the birds will become infected as they grow But there is no guarantee, some integrators will "spot test" a percentage of their breeder birds as added assurance Furthermore, they take measures to identify the breeder source of all chicks produced If there is reason to believe some breeding flocks are transmitting active organisms, the flocks can be located easily

Confirming Agglutination Test When Reactors Are Found

If the agglutination test shows that certain birds are positive (reactors) to the test, these birds are to be taken to a diagnostic laboratory for confirmation of the test This is necessary because the test is not completely accurate In such circumstances, the bird is sacrificed, and the usual cultures are taken and tests made to determine if active *S pullorum* organisms are present Remember, this test is not for antibodies, but rather for the presence or absence of active bacteria

Pullorum Still an Important Disease

Even though the blood test has been instrumental in identifying carriers of the disease, and most breeder flocks have been rid of the disease for many generations, pullorum still exists even in seemingly "clean" flocks Admittedly, outbreaks of the disease occur infrequently, but when they do, they become a major difficulty Breeder flocks must be retested, and no hatching eggs can be used from suspicious flocks until the flocks are again clean Eggs in the incubators must be sacrificed when the breeder flock is judged suspicious

When pullorum outbreaks occur in "clean" flocks, determination of the source of infection becomes important Such information may be helpful in preventing infections of other flocks During the past few years one of these sources has been found to be the feed Certain feed ingredients, particularly the animal and fish proteins, provide optimum conditions for retention and growth of many Salmonellae Some poultry producers are now having their poultry feeds pelleted, because the heat generated in the pelleting process destroys the Salmonella and some other organisms, but some pelleting processes do not produce enough heat Have a laboratory check some pellets for Salmonellae

Treatment

Death losses from pullorum disease in young chicks may be reduced when furazolidone is given to the birds The drug is quite specific against certain Salmonellae, and is bactericidal

Furazolidone dosage Add 100 gm of pure drug to each ton (2,000 lb) of

blood is placed in a small tube until the serum separates. In the laboratory the blood serum is withdrawn from the tube and mixed with the antigen, using varying dilutions If the bird is a *nonreactor* (not carrying antibodies) the mixture remains cloudy and uniform. If antibodies are present in the serum (from a reactor), a *clumping* appears, the clumps fall to the bottom of the test tube, and the solution above is clear. Another laboratory procedure involves plastic plates with tiny depressions No test tubes are used.

The two tests compared

(1) The whole-blood test is more rapid

(2) The whole blood test may be conducted in the chicken house, the tube test can be completed only in the laboratory.

(3) Birds must be banded when the blood is taken for the tube test. The band numbers must be written on the small tubes (or the tubes otherwise identified) as the blood is collected in the chicken house. The banding is necessary to identify and help locate any reactors in the flock

(4) Some feel the tube test is more reliable because specialized technicians run the test under controlled laboratory conditions. But if the whole-blood test is read by properly trained personnel there is no reason to believe it is not as valid.

(5) The cost of conducting the whole blood test is lower than that of the tube test

(6) Certain states and countries recognize only the tube test, especially if hatching eggs or chicks are to travel interstate or intercountry.

Identifying Carriers

"Carriers" sluff *S pullorum* bacteria through the egg to the newly hatched chick. When the breeders are blood-tested, these carriers should be identified and removed from the flock. To be adequately certain that all reactors (carriers) are identified, two blood tests, no less than six months apart, should be conducted. If, on a test, some reactors are found, the flock should be retested after 30 days The procedure should be continued until there are no reactors on two consecutive tests.

Why The Test is Not Infallible

The blood test has its limitations because:

(1) Cross agglutination between organisms other than *S pullorum*, particularly other Salmonellae, occurs, clouding the validity of the test. Also, there are variant strains of *S pullorum*, and if the antigen does not contain bacterial cells of such strains, the test will be unreliable.

(2) Often the test is not sensitive enough. Hairline reactors, where the agglutination in the rapid whole-blood test is only partially complete after two minutes on the plate, cause erroneous readings

(3) Infected birds do not always react to the agglutination test Some birds, particularly during the time they are in egg production, may not react to a blood test, but will react a few weeks later.

(4) Antibodies may not have made their appearance. Once a bird becomes

Diseases Confused with Fowl Typhoid

Epidemic tremor
Fowl cholera
Paratyphoid
Pullorum

External Symptoms

In comparison with pullorum, typhoid is a slowly spreading disease. The first external symptoms are ruffled feathers, loss of appetite, and a greenish diarrhea. The comb and wattles may be pale, with an anemic-like appearance. At times death in adult birds may be sudden, without any prior indication of illness. In untreated flocks mortality may run as high as 50%.

Internal Symptoms

In the early stages of the disease few tissue changes occur, but in the acute stage the liver is enlarged, and may have a color from bronze to mahogany. In some cases it may be streaked. The spleen and kidneys may be enlarged. In young chicks the egg yolk is usually unabsorbed; the liver is white and friable. The digestive tract is usually empty. As in the case of pullorum, adult carrier pullets may show atrophied ova.

Transmission

Transmission of typhoid is similar to transmission of pullorum. *S. gallinarum* organisms are passed from the infected hen through the egg to the newly hatched chick. Fecal transmission may be a more important cause of spread than with pullorum. The incubation period is from four to five days.

The organisms may be carried on the clothes of attendants, and the disease may be spread in this manner. Feed bags, insects, and rodents are capable of carrying the disease.

Fowl typhoid is widespread, but seemingly may show no evidence for long periods, then outbreaks occur. Transmission to unaffected birds is rapid in such cases. Outbreaks may occur several times a year.

Diagnosis

The diagnosis is the same as for pullorum. Agglutination tests may be used to determine if adult birds are carriers. A laboratory diagnosis is the only accurate means of determining the presence or absence of *S. gallinarum* organisms. The organism grows readily on most laboratory media, and may be identified either bacteriologically or serologically.

Since most antigens used for conducting the *S. pullorum* agglutination test are polyvalent (containing pullorum variants), and since *S. gallinarum* will cross-agglutinate with *S. pullorum*, it is unnecessary to run a specific agglutination test using only *S. gallinarum* bacteria. Thus, the so-called blood test for *S. pullorum* is really not specific for this organism; a reactor to the test might be affected with either or both diseases.

Control

Eradication of the carrier birds in the breeder flock should be the first line of attack in handling an outbreak of typhoid in young chicks. Depopulation of the

feed (0 011%) until the disease subsides, (usually two weeks), then reduce to 50 gm per ton (0 0055%) for another 2 or 3 weeks

Note Although furazolidone will destroy *S pullorum* organisms in the blood, it has no effect on those in the intestines Thus, the bird is alleviated of the disease, and ceases to transmit *S pullorum* through the egg, but transmission through the droppings continues

Important When furazolidone is fed to laying hens the birds are sterilized of Salmonella and eventually become negative to the agglutination test Furthermore, the bird no longer sluffs *S pullorum* organisms to the eggs she lays Feeding the drug will interfere with the agglutination test, as some birds, although not sluffing fecal organisms, will continue to harbor organisms in some partially atrophied ova As these release a few antibodies into the bloodstream, the authenticity of the agglutination test is affected Of even greater importance is the fact that cessation of the production of *S pullorum* bacteria will make it impractical to arrive at any type of diagnosis when birds are cultured in the laboratory Important too is the fact the birds will recover from infection, but the drug does not change a sero reactor to a negative

Caution for using furazolidone when blood testing Do not feed this drug (or most other drugs) the week before completing any agglutination test or submitting birds to a laboratory for diagnosis of pullorum

What to do when the disease strikes Evidence of the disease in a group of chicks is the first indication that in all probability the breeders are sluffing viable bacteria through the hatching eggs The breeders literally have infected the chicks In such a case

(1) If the breeder flock from which the hatching eggs came can be identified, do not use eggs from this flock until the diseased birds have been eliminated

(2) Remove from the incubators any eggs from this flock

(3) Disinfect and fumigate all hatchery equipment thoroughly

(4) Blood test all the birds in the suspicious breeding flock Remove all reactors to the test, then after 30 days, test again Repeat the procedure until there are no reactors on two successive tests

Can infected chicks be saved for future breeders? Recovered birds or flocks should not be saved for breeding purposes unless several blood tests on adult birds show no reactors

FOWL TYPHOID

Fowl typhoid is a septicemic disease similar to pullorum, except that mortality from typhoid may occur at any age, it is not confined to young chicks, as in the case of pullorum See section on PULLORUM

Cause

Fowl typhoid is caused by a bacterium, *Salmonella gallinarum* In many respects the organism acts like that of *Salmonella pullorum* Most species of poultry susceptible to pullorum are also susceptible to typhoid The typhoid organism grows and develops inside the body in a manner similar to *S pullorum*

Cause

Paratyphoids have worldwide distribution. The cause of the specific infection is the result of infection by one of the Salmonellae in the paratyphoid group. The life cycle and method of dissemination are similar to *S. pullorum*. *S. typhimurium*, a serotype, is one of the most troublesome for the poultryman. Especially involved is the turkey, although chickens also are affected. Most turkey breeders use an antigen specific for *S. typhimurium* in their blood-testing program for pullorum.

Symptoms

There seem to be no specific external symptoms, probably because of the wide variety of organisms involved. In some cases the young chicks are listless, and there may be a diarrhea, but some affected flocks show no visible evidence of the disease. In many outbreaks, the disease causes two definite periods of death losses, one at four to five days of age, another at ten to 12 days.

Internally, few symptoms are noticeable, but none are specific; they easily may be confused with those produced by *S. pullorum*.

Transmission

In general, transmission is similar to that of *S. pullorum*, but certain modes are of more importance.

(1) *Egg Transmission:* Paratyphoid definitely is egg-transmitted, but eggshell penetration is more important than in the case of *S. pullorum* and *S. gallinarum*. Eggshells are abundantly covered with paratyphoid organisms as the egg passes through the cloaca; when the egg is laid these organisms are sucked through the shell pores, an avenue of chick inoculation. Contaminated nesting material is a major source of the organisms on eggshells.

(2) *Fecal contamination:* The paratyphoid organisms are found in great numbers in the intestinal tract; this accounts for the greatest amount of transmission from bird to bird.

(3) *Ovarian transmission:* Paratyphoid organisms lodge in the ovary; this represents a possible method of transmission of the disease from dam to the newly hatched chick. In most cases, however, there is little ovarian transmission. Young chicks can be infected but will not show evidence of the disease until they are stressed.

(4) *Personnel:* People are capable of transmitting paratyphoid. Organisms are carried on clothing and footwear from one location to another. The bacteria are capable of surviving outside the host for many weeks.

(5) *Feed:* As with pullorum, the paratyphoid organisms may live in certain feed ingredients for long periods.

Diagnosis

A laboratory diagnosis is necessary to ascertain the paratyphoid involved. Bacteriological methods generally are used. Although the diagnosis is more or less definite in young chicks, trying to type the organisms taken from adult birds may not always lead to conclusions because no sickness or other evidence of the disease is present. Many times it is more practical to culture embryos after ten days of incubation to determine any correlation with paratyphoid infection in the breeder flock.

entire breeder house generally is not a practical means of control, but in severe cases such a procedure may be the only method, testing every 30 days to remove the reactors could become an uneconomical and lengthy process. Usually when the percentage of reactors on the first test after a disease outbreak is less than 5%, blood testing may be used, if 20% or more, the flock should be marketed

Treatment

As with pullorum, furazolidone is the drug most often used in treating birds affected with fowl typhoid Antibiotics seem ineffective

Dosage Add 100 gm of furazolidone to a ton (2,000 lb) of feed (0 011%) Feed the mixture for 2 weeks to chicks or older birds, then reduce the medication to 50 gm per ton (0 0055%) for another 2 or 3 weeks

Caution Fowl typhoid is peculiar in that the disease may reappear after administration of furazolidone In chicks another treatment will then be necessary In the case of adult breeder birds, complete eradication of infected birds from the laying flocks will be necessary When the adult birds are commercial layers, rather than breeders, continuous medication at the rate of 50 gm of furazolidone per ton (2,000 lb) may be necessary after the initial level of 100 gm, not only to keep the disease under control in the affected flock, but to prevent the spread to other flocks on the farm Furazolidone prevents passage of *S gallinarum* organisms in the droppings Blood testing commercial egg laying flocks (and removing the reactors) does not seem economically feasible

Sanitation program of great importance Fowl typhoid is easily spread from house to house and farm to farm A complete program of ioslation and quarantine of infected flocks must be undertaken Employees assigned to affected houses must not be allowed to visit or work in other areas of the farm Visitors should not be allowed on the farm Trucks and other equipment must be sanitized regularly All litter should be removed from affected houses and burned The disease spreads more rapidly when the surroundings are dirty than when they are clean

PARATYPHOID

Besides the Salmonella organisms *S pullorum* and *S gallinarum*, over 50 other Salmonellae have been isolated from domestic fowl These have been grouped as "paratyphoids" Important ones are *S typhimurium*, *S montevideo*, *S derby*, *S meleagridis*, *S newport*, *S bredeney*, and others They are quite stable, some can survive moderate heat for long periods, most can live for weeks in media such as water, feed, human food, and soil Many can infect humans when they are in a weakened condition as well as chickens, and therefore take on an aspect of great significance Some illnesses in humans have been traced to Salmonella infections, and when these same organisms are found in, or on, the tissues of dressed fowl, or in eggs, suspicion is aroused that they might be the contributing source of the disease in people This has caused the poultry industry to take extreme measures of sanitation in poultry processing plants

Other Names

The paratyphoids usually are given a species name according to the area in which they were first isolated Their common name generally is the same

marble. The disease may affect the inner ear, causing a twisting of the head, and an unsteady gait. Some birds may appear lame.

Internal Symptoms

There may be very small hemorrhages on the liver, and sometimes on the heart and intestines. The liver may be enlarged. The disease takes on the form similar to that encountered with CRD. The air sacs may contain lesions; and the heart sac is enclosed in a yellowish-appearing film. Other organs can be affected.

Transmission

The organism responsible for fowl cholera may be passed easily from bird to bird. It will enter the body through either the respiratory or digestive tract. Transmission can be by people, clothing or footwear, and through contaminated feed and water. A healthy bird pecking at a contaminated bird may be a means of spreading the disease through the blood or nasal exudate. Wild birds harbor the organism, indicating at least one reason why range-grown birds have a high incidence. Ulcerated wattles are a source of infection. The disease is not known to be egg-transmitted.

Diagnosis

Fowl cholera can be diagnosed accurately only in the laboratory. The method is bacteriological; the organism is isolated and identified. The test should take no longer than 24 to 48 hours.

Treatment

The treatment of an outbreak of fowl cholera may be plagued with pitfalls. Some flocks respond to treatment; others do not. The age of the birds—growing or laying—will affect recovery. The type of cholera encountered affects the results.

Treatment of growing birds.—This involves the use of sulfonamides. Sulfaquinoxaline is used extensively for growing birds. Administering sulfonamides for a period of a few days may bring the disease under control and reduce mortality, but relapses are frequent once the drug is withdrawn.

Dosage: Sulfaquinoxaline should be fed at the rate of 0.1% of the feed for 2 or 3 days, then should be reduced to 0.05% for several more days. Continuous feeding at the lower level can develop sulfonamide anemia, but it may be necessary to feed sulfaquinoxaline for a period of 5 to 6 weeks at 0.05% until the organisms subside.

Sulfadimethoxine: This drug should be added to the drinking water at recommended dosages in place of using sulfaquinoxaline in the feed.

Caution: Sulfonamides supress the growth of bacteria but do not kill them. They also have coccidiostatic powers, and *when they are withdrawn, care should be taken to provide adequate coccidial control.*

Streptomycin: Streptomycin may be injected intramuscularly, the dosage being correlated with body weight.

Racephenicol: Another drug used for the treatment of cholera is racephenicol, which should be administered in the feed. It should be used only for young birds and for mature birds *not producing eggs for human*

Treatment

Most of the time paratyphoid is not a major disease of chickens, as the disease is usually limited to the region of the intestinal tract. Because of some cross-agglutination when the pullorum blood test is made, many adult carriers of paratyphoid are eliminated from the breeding flocks.

Where carefully diagnosed cases do appear in young chicks, the use of furazolidone at 200 grams per ton (2,000 lb) for two weeks, or until losses stop, followed by a 100-gm level for 2 or 3 more weeks should suffice to prevent the spread of the disease. Be sure no drug bearing a nitro grouping is being fed when furazolidone is administered. The combination produces nervous symptoms in the birds. Sulfonamides also have been shown to have merit.

There is little evidence to show that treating the breeder flock with medicaments to prevent egg transmission of paratyphoid via infected ova is of any consequence, although some drugs may act indirectly to destroy some organisms in the intestinal tract, thus decreasing the number of bacteria deposited on the eggshell.

FOWL CHOLERA

Fowl cholera has been one of the most baffling of poultry diseases. Until bacterins and sulfa drugs entered the field, there was little that could be done to alleviate the condition in an infected flock. Although better sanitation programs, along with less range rearing of growing birds, have brought about a reduction in the incidence of the disease, there still are many outbreaks, and they still are difficult to control. The disease is very important with turkeys, probably because many are grown on the ground, and turkeys seem more susceptible.

Cause

The disease is due to a bacterium, *Pasteurella multocida* Normally, cholera may be either acute or chronic.

Diseases Confused with Fowl Cholera

The disease has worldwide incidence and affects many poultry species Migratory birds are involved, and are a means of dissemination. Confused diseases are:

- Blackhead disease
- Chronic respiratory disease (CRD)
- Fowl typhoid
- Hepatitis

External Symptoms

Acute form Usually, the first observation of the disease is a high incidence of birds dead on the floor or roosts, or in the nests, many times without any obvious external or previous symptoms Mortality is rapid; 50% or more of the birds may die Birds between 12 and 18 weeks of age seem very susceptible. Range-grown birds have a high incidence of infection. There may be a greenish-colored diarrhea.

Chronic form Death losses are relatively light from the chronic form. The most obvious symptom is a swelling of the wattles, particularly in male birds. Adult birds show more of this symptom than young One or both wattles appear swollen from a cheesy, hard deposit, often resembling a

be considered a temporary measure; the organism must be eliminated from the farm.

Precautions

Although the above recommendations for treatment may seem to belittle the importance of the disease, it must be remembered that many such treatments do not produce remedial effects. The disease may drag on in the flock or on the farm for long periods. Some birds may develop a resistance to the sulfonamides, while others will show little response to the bacterins. Other drugs must be used. Chlortetracycline may be given, but only at very high levels of 500 grams per ton (2,000 lb). This level is uneconomical unless potentiation of the drug is used.

OMPHALITIS

Omphalitis is a disease that affects chicks when they are hatching. It results in a failure of the umbilical opening to heal normally.

Other Names

Mushy chick disease
Navel infection

Cause

Omphalitis is a disease of general bacterial infection due to several organisms. They may be Coliform, Staphylococcus, Pseudomonas, or other types. Bacteria invade the umbilical tissues as the result of improper conditions in the hatcher. The navel opening does not close, and infection passes to the internal organs.

Diseases Confused with Omphalitis

Pullorum
Typhoid
Paratyphoid

Symptoms

The chicks seem weak, huddle together, and may have a watery diarrhea. Upon close observation, an infected and open umbilical area will be noticed. It will be discolored to bluish black. There is a very noticeable pungent odor, characteristic only of this disease. The abdomen feels soft, mushy, flabby, and enlarged. The infection may carry to the internal organs, particularly to a portion of the intestines. Peritonitis may be found. Mortality may run as high as 10 to 20%.

Transmission

The disease is very infectious, and death occurs within two or three days after hatching. The seat of the infection is the incubator (hatcher). The ventilating fans quickly disseminate the organisms, which find the unhealed navel a likely seat for infestation. Once the chicks are in the brooder house, the likelihood of transmission from chick to chick is very low, although possible.

Diagnosis

Suspected chicks should be submitted to the laboratory for diagnosis. A bacteriological examination for causative organisms will identify the disease.

consumption Two dosages are practical

(1) Feed at the rate of 100 gm per ton (2,000 lb) (0 011%) of feed for 10 days Withdraw 48 hours before slaughter

(2) In more severe cases, administer at the rate of 200 gm per ton (2,000 lb) (0 022%) of feed for 5 days, then reduce to 100 gm per ton (2,000 lb) (0 011%) for another 5 days Withdraw 48 hours before slaughter

Note Racephenicol should be added to mash feeds only and consumed within 45 days of manufacture

Treatment of laying birds —High level feeding of sulfaquinoxaline is a deterrent to egg production Therefore, other means of controlling the disease in laying flocks must be used The procedure is through the use of a bacterin Several are on the market, most of which contain several strains of *Pasteurella multocida* But because variant strains of the organisms may arise on a farm, there is little assurance that the prepared mixtures contain the strain involved in the disease outbreak As an alternative, some hens with fowl cholera may be taken to the laboratory where the organism is to be isolated and an autogenous bacterin made using the recovered bacteria The laboratory also should be instructed to retain the cultures so that future bacterins may be produced from the same strain The bacterin should be injected subcutaneously or intramuscularly into the laying birds and males according to directions at six week intervals

Type of bacterin In producing a bacterin the bacteria may be suspended in oil or water The oil type bacterins have an advantage, since the oil solution is absorbed more slowly than the water type, thus the dosage is spread over a longer period With aqueous solutions the initial dosage provides a higher level of the drug and thus may have an advantage of greater immediate potency

Bacterins do not produce beneficial results in all cases, sometimes they are effective, but often they are not

Caution when feeding sulfaquinoxaline to layers Sulfaquinoxaline produces a reaction in laying birds At high levels of intake, egg production may drop to almost zero Sulfaquinoxaline should not be fed to laying birds at levels higher than 0 0125%, and only for periods of 2 or 3 days at a time It should then be withheld for the same length of time before repeating the dosage

Sulmet This drug has long been used in the treatment of fowl cholera

Sulfadimethoxine A relatively new drug, sulfadimethoxine is said to be effective in the treatment and prevention of cholera There is a water form and feed form of the drug

Racephenicol This is another new drug used for the control of fowl cholera

Cleanliness The treatment process must incorporate a complete cleaning and sanitation program The organism is transferred easily from bird to bird and place to place All dead birds should be cremated

Control

The only satisfactory method for the control of cholera is by eradication Treatment of growing pullets or laying hens either with drugs or bacterins should

Internal Although the symptoms are usually external, there may be some distress in the air sacs

Mortality Death loss from coryza usually is low, but continued infection in the laying flock creates a loss of appetite, and egg production drops

Transmission

There are two major means of transmission of the disease

(1) *Through the drinking water* Contamination of the drinking water from the infected discharges probably is the main method of dissemination The organisms can remain viable in nonsanitized drinking water for several hours

(2) *Airborne* Certain carrier birds transmit the disease to others during periods of stress—moving, vaccination, changes in temperature, etc This triggers a general outbreak in the flock

Diagnosis

Although visible evidence of the symptoms in the birds usually is enough to diagnose most cases of infectious coryza, laboratory techniques should be employed for positive proof These techniques are

(1) Identification of the organism

(2) Bird inoculation Nasal exudate from infected birds dropped into the nostrils or eyes of young birds usually will reproduce the disease in two days

Treatment

The sulfonamides are quite specific in their coryza-control properties Other drugs, such as oxytetracycline, erythromycin, and streptomycin are less productive The mycins should be administered by injection

How to use sulfonamides The high level of intake of these drugs required to be effective in the treatment of the disease is great enough to depress egg production Therefore, they should not be used at full dosages in the treatment of laying flocks Sulfathiazole at 0 5% in the feed is the recommended dosage, but it affects egg production at this level Sodium sulfathiazole may be used in the drinking water Sulfadimethoxine also may be used The drugs do not destroy the organisms, but only supress their reproductive powers Consequently, after the drugs have been withdrawn, coryza may reappear It is this fact that makes the disease so troublesome, and so difficult to obliterate Young birds, prior to egg production, may be treated with sulfadimethoxine at 0 5% in the water for as long as two months if continual observation indicates there are no side effects, particularly anemia

Effective treatment of laying flocks is difficult, and treatment is accomplished by feeding low levels of the drugs for periods of three to four days, then repeating the dosage after a rest of two or three days

Sulfa drugs highly anticoccidial After withdrawal of any sulfa drug care should be taken to provide some effective means of coccidiosis control

Control

Preventing outbreaks of infectious coryza is most difficult because of the nature and ease of transmission of the organism responsible Several items are involved

Treatment

If the chicks in the brooder house appear chilled, increase the brooding temperature Although antibiotics or nitrofurans may check the disease in the brooder house, the possibility is very remote, little can be done In fact it is better that the infected chicks die

Control

When an outbreak occurs in the hatchery everything must be fumigated with formaldehyde gas Use 3X strength where possible Lower concentrations are not effective in destroying all responsible organisms

Caution Incubating eggs (1–19 days) should be fumigated at 2X (double) strength, never more, for this procedure

Hatchery rooms and all equipment must be fumigated every second day until the infection is destroyed Also, use a good liquid disinfectant where practical

Remember An outbreak of omphalitis on the poultry farm is almost always the result of an infection in the hatchery Extra measures must be employed to rid the hatchery of the organisms responsible, and to keep it clean thereafter

INFECTIOUS CORYZA

This was a serious disease of most farm flocks of chickens a few years ago, but with the practice of more rigid sanitation on poultry farms its incidence has waned However, in highly concentrated poultry areas, particularly those involving caged layers, it is still a major problem

Other Names

Colds
Hemophilus gallinarum infection
Roup

Cause

The disease is due to a bacterium, *Hemophilus gallinarum* This is a relatively weak type of organism, and although easily spread from bird to bird, it cannot live outside the body of the chicken for longer than 5 to 6 hours

Diseases Confused with Coryza

Fowl pox When pox affects the eye it could be confused with coryza, but in most instances there will be pox lesions on the comb
Chronic fowl cholera
Vitamin A deficiency

Symptoms

External The disease may affect birds of all ages Usually the first sign is sneezing This is followed by a watery condition of the eyes, then a discharge in the nasal and sinus passages Mucus may be squeezed from the nostrils As the disease continues these areas become filled with cheesy exudates, particularly the sinuses Swelling occurs, and lumps of material appear in the sinuses below the eyes The mouth and nostrils have a peculiar odor

coli bacteria produce their effects by being secondary invaders. When coccidiosis is involved along with E. coli infection there is the question of which was there first. The fact that coliforms are ever-present in the intestinal tract makes the differentiation most difficult.

Incorrect diagnosis a problem: Because the lesions of the intestinal tract produced by *E. coli* and coccidiosis are similar, care should be taken to arrive at the correct diagnosis. Continued treatment for coccidiosis when the disease is caused by *E. coli* can only aggravate E. coli infection and lead to more serious complexities.

Coli Septicemia

The next step in coli infection is coli septicemia, when toxins and bacteria enter the blood stream after the toxin produced by the coli organisms ruptures the intestinal wall. Such lesions allow the organisms to gain entrance to the portal system. In turn, they find their way to the kidneys, a blood-filtering organ. As the filtering continues, the kidneys become congested and enlarged. The liver is next, and it too, becomes enlarged, its edges rounded, and its surface speckled. The discolored areas enlarge when the organisms kill sections of the liver tissue.

Air-sac Infection

Eventually *E. coli* involve the air sacs, the organisms arriving by way of the blood stream. Airsacculitis results, and the birds cough and wheeze. Morbidity, rather than mortality, becomes the economic problem, especially in broilers, where birds with infected air sacs will be condemned in the processing plant as unfit for human consumption.

But the *E. coli* organisms may find their way to the air sacs by a more direct path. They may enter the upper respiratory tract through the routine of breathing, and soon settle in the thoracic air sacs, then eventually find their way to the abdominal air sacs. When infection reaches its height, the air sacs become filled with a yellowish, cheesy material. A similar material also surrounds the heart and lungs.

Is E. coli infection secondary in the air sacs? Originally it was thought that the *E. coli* organisms gained entrance to the lining of the air sacs only after the cells in such an area were first invaded by PPL organisms, but late evidence indicates that E. coli infection may be possible on its own. The responsible organisms are not necessarily secondary invaders.

Diseases Confused with E. Coli Infection

- Blue comb disease
- Cholera
- CRD (chronic respiratory disease)
- Typhoid

Transmission

There are several means of *E. coli* transmission:

(1) *Fecal:* Organisms in the intestinal tract are continually being sluffed through the fecal material, and in turn these bacteria dry and float in the air and gain entrance to uninfected individuals by way of the respiratory tract. Of significance in this mode of spread is the fact

in such a program

(1) *Keep only birds of the same age on the farm* Depopulation of the premises under such a program prevents older carrier birds from infecting younger birds

(2) *Use a bacterin* Bacterins specific for *H gallinarum* have been prepared and used, mainly with growing birds The bacterins are prepared from organisms specific to the flock or area involved In some instances these have been successful, in others, they have not Their longevity of immunity is not great, and their ability to suppress the disease completely is highly variable The bacterin is specific only for the airsacculitis form of the disease, hence all coryza outbreaks will not be resolved Furthermore, the *H gallinarum* used to produce the bacterin must be antigenically similar to that in the field Bacterins may give protection for periods of 10 to 20 weeks

(3) *Artificially infect the chicks early in life* In some instances young flocks have been infected with coryza at an early age so that the birds recover before egg production begins Often the artificial infection is given two to three weeks after the bacterin This method should be approached with caution

E COLI INFECTION

The coli organisms are responsible for a variety of poultry diseases with a wide variation in manifestation The *Escherichia coli* (*E coli*) are bacteria which represent one of many of the coliform group of organisms inhabiting the lower intestinal tract Some are harmless, and are called saprophytic, these aid in the process of digestion Others are pathogenic, and produce certain poultry diseases Although most are harmless, the few pathogenic ones are capable of producing high mortality and morbidity with serious economic loss

Other Names

Air-sac infection
Colibacillosis
Coli enteritis
Coli septicemia

Specific Diseases

E coli are responsible for several types of diseases, namely,

Air-sac infection	Coli septicemia
Bumble foot	Egg peritonitis
Coli enteritis	Yolk-sac infection
Coli-granuloma	

Only the important diseases produced by *E coli* organisms will be discussed

Coli Enteritis

The organisms, located in the upper portion of the intestinal tract, cause it to become congested with small blood vessels Some rupture, causing hemorrhages very similar to those occurring in coccidiosis

Nodules also may appear in the cecal lining, but whether the coli organisms are primarily responsible for the intestinal and cecal disorders is not known Most

ARIZONA DISEASE

Certain paracolon organisms similar to the paratyphoid group are classified as Arizona type There are several serotypes Specific laboratory techniques are necessary for identification The organisms are Gram negative and usually motile

The Arizona strains are found worldwide, and have been isolated from chickens, turkeys, ducks, parrots, canaries, and some mammals

Symptoms

The prevalence of Arizona infection in chickens is less than in turkeys, however, the disease may take on major proportions The symptoms are not well-defined In young birds there may be diarrhea, listlessness, and sometimes nervousness In older birds, paralysis of the legs, fatty degeneration of the liver and congestion of the kidneys occur

Mortality

Mortality may range from a very few birds to over 25%, depending on the involvement of the infection

Transmission

Since Arizona disease is closely related to the paratyphoids, the modes of transmission are similar Egg transmission is a major means of spread The hatchery may become contaminated, and organisms can be disseminated to distant places through chick shipments Bird to bird transmission is direct and fast For this reason an infectious outbreak in the flock affects practically all the birds Most of the transmission is through the feed and water after they become contaminated with fecal material from infected birds

Treatment

Medicaments used for flocks infected with paratyphoid are suitable for treating birds with Arizona infection Although there are some new drugs that are evidently effective, furazolidone is the popular drug used

Furazolidone administration In an infected flock the use of furazolidone at the rate of 200 gm per ton (2,000 lb) of feed for 14 days, followed by 100 gm per ton (2,000 lb) for 2 weeks will help prevent the spread to uninfected birds Because the drug does not prevent the multiplication of organisms in the intestinal tract, many birds remain as carriers

Control

Medication is not an acceptable practice for the elimination of Arizona disease from the poultry farm There must be a program of eradication However, it is more difficult to eradicate the Arizona group of organisms than pullorum or paratyphoid infections Arizona bacteria are more stable in the presence of formaldehyde fumigation, and at least a 3X concentration is required to destroy the organisms See Chapter 9 Therefore, it is not possible to accomplish much kill when incubating eggs are fumigated at double strength

Rodents are carriers, and should be eliminated through a definite program

that the intestinal organisms are almost immune to the production of antibodies, thus the *E coli* organisms continue to reproduce in the intestines and birds may remain carriers for a long period of time

(2) *Eggshell contamination* As the completed egg lies in the cloaca prior to being laid, it becomes contaminated with the excrement of the intestinal tract, including *E coli* More bacteria are added to the shell when the egg remains in the nest Subsequently, some organisms enter the egg contents and reach the developing embryo with resultant loss in hatchability and chick quality

(3) *Respiratory* As air-sac infection from *E coli* can be the result of infection through the respiratory tract, contaminated dust in the poultry house can be a direct cause of transmission

(4) *Ovarian* Transmission through the ovary is possible when birds are shedding the *E coli* organisms through uterine infection Infected breeder hens thus transmit the disease to the newly hatched chick

(5) *Feed* Although not a primary route of infection, coliforms may gain entrance to the body through contaminated feed

Diagnosis

A laboratory test is the only satisfactory method of accurate diagnosis Coliforms are isolated and classified

Treatment

Furazolidone at the rate of 100 gm per ton (2,000 lb) of feed has definite merit Some broad-spectrum antibiotics also may be used However, drug treatment for the airsacculitis form of *E coli* infection may be of little value, especially when the disease is in the latter stages

Antibiotic sensitivity test *E coli* organisms are not uniform in their sensitivity to antibiotics Some strains of the organism develop a high degree of resistance, particularly after the drug has been fed for a long period In other cases, the organism may be more sensitive to one antibiotic than to another When in doubt as to which antibiotic to use for medication, a sensitivity plate test should be run in the laboratory This will show which antibiotics (or combinations) have the greatest effect on killing the coliform organism involved in the flock

Control

Continued treatment on a farm should not be used as a means of control, the practice should be replaced by preventive measures

Control revolves around eggshell fumigation with formaldehyde or spraying with decontaminants, and reducing stresses which eventually lower the resistance of the bird enabling *E coli* to gain a foothold Other parts of the program of prevention are

isolation of the flocks,
control of wild birds and rodents
vaccination programs that do not induce stress
pelleted feeds

fested by a severe drop in egg production. High-laying flocks may drop to the production of but a few eggs a day. After the disease subsides, the return to normal egg production may take several weeks. Egg quality undergoes a drastic change. Eggs are soft-shelled, misshapen, and wrinkled; eggshells are porous, chalky, and light in color. Albumen quality is poor. Even though egg production eventually may return to normal, egg quality seldom does.

Many birds become internal layers, making visits to the nest without laying an egg. Mortality generally is negligible. The disease lasts from 4 to 10 days.

Internal symptoms Posting shows a mucus in the trachea, nasal passages, and sinuses. The air sacs of young chicks may contain cheesy deposits. In older birds there may be a low incidence of lesions, and in many instances there are none.

Transmission

Bird-to-bird transmission is by means of organisms being carried.

(1) *By the air.* It takes but a few of the virus organisms to infect a bird. As the virus is easily airborne, inhaling infected air is the most important means of spread

(2) *By people, birds, and animals* This represents a major means of spread from house to house and farm to farm

(3) *By equipment, etc*

(4) *In or on the feed*

Diagnosis

Diagnosis of infectious bronchitis is difficult, it is often made by eliminating the incidence of other similar diseases as causative agents Newcastle disease and laryngotracheitis are two such. The serotypes of the bronchitis virus must be tested separately in the laboratory for an accurate diagnosis This is very time-consuming, and in most instances the disease will have run its course before the tests can be made. The procedures usually followed in the laboratory are:

(1) serum neutralization (SN) test;
(2) virus isolation test,
(3) hemagglutination test;
(4) fluorescent antibody test.

Treatment

There is no known treatment for infectious bronchitis. However, when secondary infections are in evidence, treatment for these may alleviate the damage to the bird. Laboratories making post mortem and laboratory examinations usually will analyze the situation thoroughly for the presence of accompanying diseases.

Control

Control of infectious bronchitis is by vaccines of established type and quality. Live, attenuated types are recommended. The vaccine used will depend on the age and type of bird.

INFECTIOUS BRONCHITIS

Infectious bronchitis is a disease affecting chickens in every part of the world It is a serious affliction of young chicks, causing high mortality In laying birds it entails a great economic loss through reduced egg production and eggshell quality The chicken is the only bird known to be susceptible

Other Names

Bronchitis
Gasping disease
IB

Cause

The disease is caused by a filterable virus There are ten or more recognized serotypes In instances some of the serotypes produce cross immunity Two of the best known serotypes are

Massachusetts type
Connecticut type

Note

(1) The Massachusetts strain produces the severest type of the disease
(2) The Massachusetts strain produces cross immunity with the Connecticut strain
(3) The Connecticut strain produces a poor cross immunity with the Massachusetts strain

Diseases Confused with Infectious Bronchitis

CRD
Laryngotracheitis
Newcastle disease

Symptoms

The disease produces symptoms varying with age, chicks and adult chickens are *affected differently*

Infectious bronchitis in chicks In young chicks there is a noticeable wheezing and sneezing, particularly at night There may be a nasal discharge, watery eyes and swollen sinuses The birds gasp for breath The disease has rapid dissemination following almost instantaneous onset Mortality may run as high as 50%, morbidity affects practically all the birds The disease affects the immature reproductive system of the young pullet chick, leading to a reduced performance in the laying house

Secondary invaders follow The severity of the disease is associated with the damage done by secondary diseases, particularly those produced by the coliforms

The incubation period of infectious bronchitis is from 18 to 36 hours Usually the disease will run its course in 5 to 20 days, but the effects of secondary invaders may linger for long periods of time

Infectious bronchitis in adult birds As in chicks, the disease starts fast, without notice Infection from bird to bird is rapid However, there are few noticeable symptoms involved with the bird itself, the disease is mani

Bronchitis-Newcastle vaccine combination comments:

(1) Bronchitis virus vaccine multiplies more rapidly than Newcastle vaccine and the bronchitis growth may interfere with the growth of the Newcastle virus.

(2) Newcastle virus vaccine is more stable than bronchitis vaccine. Deteriorated mixed vaccine is more likely to produce immunity to Newcastle disease and not to bronchitis.

(3) There is more variability in the potency of bronchitis vaccine than of Newcastle vaccine.

Establish the titer: There may be failures of bronchitis disease vaccinations due to improper vaccinating methods, deteriorated vaccine, parental immunity, and other causes. In order to ascertain the potency of the immunity, titers should be established by a competent laboratory technician. If the titers are low, the birds should be revaccinated.

NEWCASTLE DISEASE

Newcastle disease was named from the town in which it was first diagnosed, Newcastle, England. A highly infectious disease, in some areas of the world it takes on increasing virulence, adding to its importance.

Other Names

Avian pneumoencephalitis
Fowl pest
ND
Ranikhet disease

Cause

The disease affects chickens, turkeys, pheasants, and many other birds. It is due to a filterable virus, and there is but one serotype. However, there are 3 general forms. One, termed the U.S.-type, is worldwide. Another, and more virulent form, is prevalent in certain areas of the Middle East and Far East. Still another, (velogenic) has a higher virulence. Several strains of Newcastle disease viruses have been isolated. The important ones are:

LaSota strain (B_1 type)—velogenic
Hitchner (B_1 strain)—lentogenic
F strain—lentogenic
Roakin—mesogenic

Each of the above strains has its place in vaccination; for instance, certain ones are more applicable to wing-web vaccination than others, as explained later.

Diseases Confused with Newcastle Disease

Avian encephalomyelitis (AE)
CRD
Infectious bronchitis
Infectious coryza
Laryngotracheitis

Symptoms

Symptoms vary according to the age of the bird:

Young chicks: Chicks gasp, cough, and breathe with a rattling sound. In

General recommendations for type of vaccine As most serotypes will produce cross immunization with the Massachusetts strain, it should be considered as the main component of most bronchitis vaccines However, many mixed vaccines, containing both the Massachusetts and Connecticut strains, are on the market, and may be used under certain conditions

Important Polyvalent vaccines (containing more than one strain) are more likely to produce a greater stress following vaccination than those that are monovalent This may be a disadvantage in some instances Vaccines composed of some serotypes other than the Massachusetts and Connecticut strains may produce kidney damage, and therefore are not generally suitable for vaccine preparation

How vaccines are administered Vaccines may be classified according to their means of administration as

nasal or ocular,
water,
dust,
spray

Although each has its advantages and disadvantages as outlined in Chapter 40, those methods that are likely to produce less stress along with greater uniformity of administrative dosage are more practical

Vaccination of broilers Broilers should be vaccinated only in areas where the disease has taken on acute proportions The reasoning behind this is that the stress and side diseases produced by bronchitis vaccination may cause greater flock morbidity than the disease itself

When vaccination is practiced, the vaccine should be administered when the chicks are from 14 to 21 days of age, after most parental immunity has dissipated

Method of vaccinating broilers Most broiler flocks are vaccinated with a water type vaccine, or the vaccine may be given ocularly or intranasally Occasionally dusts or sprays are used The water type is more often used because of the ease of administration Seldom is a second vaccination given to broilers, since the birds are marketed between eight and nine weeks of age

Method of vaccinating breeder replacement chicks The method of vaccinating young replacement chicks usually is the same as that used for broilers One vaccination is given at two to three weeks of age, it is followed by another at seven to eight weeks of age The latter is used to increase the immunity produced by the first vaccination

Method of vaccinating breeders in egg production The longer the period after vaccination the more the immunity decreases, and as the presence of antibodies in the blood of the laying, breeder hen passes on parental immunity to the chick, it becomes necessary to revaccinate the breeders to produce uniformity of parental immunity in the offspring This program calls for administering a bronchitis vaccine once every ten to twelve weeks during the laying cycle

Combination vaccinations Bronchitis vaccine sometimes is combined with Newcastle disease vaccine and birds are vaccinated for both diseases at one time, and in the same manner

extreme care must be followed in carrying out the programs. Even then there are some failures. Variations occur because:

(1) Strains of the virus differ with various vaccines.
(2) Potency of the vaccine differs at time of manufacture.
(3) Killed and live viruses are used to make vaccines.
(4) Deterioration of the vaccine causes wide variation in its efficacy.
(5) Mode of administration of vaccine varies (dust, water, wing web, etc.).
(6) Administration may not be uniform with each bird as the result of the method of administration.
(7) Parental immunity in the bird influences the degree of "take."
(8) Season of the year influences the bird's acceptance of the vaccine.
(9) Various vaccines differ in developmental stress of the birds.
(10) ND vaccines are often mixed with vaccines used for other diseases, e.g., infectious bronchitis.

Two Forms of Newcastle Disease

Newcastle disease has two forms:

(1) respiratory type;
(2) nervous type.

Differences in the two types: The virus localizes in the respiratory tract, and all infected birds show an incidence of the respiratory type. Nervous symptoms arise later, and may or may not be present. Older birds seldom show any manifestation of the nervous system.

Vaccination Procedure

If Newcastle disease is in the area, all birds on the flockowner's premises should be vaccinated. Transmission from farm to farm is too easy to justify any risks.

Vaccinating young chicks: Young chicks, both broilers and breeder replacement chicks, should be vaccinated at an early age, but only after parental immunity has subsided. This is never before the chicks are 14 days of age; preferably they should be 21 days old.

Important: Parental immunity is the result of antibodies in the chick. But because these are confined to the bloodstream they do not give protection when the Newcastle virus enters the bird by way of the respiratory tract. Thus, parental immunity does not protect the chick from natural outbreaks of the disease.

B_1 strain of virus best used for chick vaccination. B_1 strain (La Sota) is a mild strain of vaccine and can be used on young chicks without undesirable effects. There are no respiratory or nervous symptoms, nor any spread of the virus from chick to chick. Water, ocular, or intranasal methods of vaccination may be used.

Wing-web vaccines not to be used for young chicks: Wing-web vaccines enter the bloodstream through the puncture made by the needle used in vaccinating. Here any antibodies destroy the virus rather than allowing the virus to produce more antibodies. Wing-web vaccines are ineffective in the presence of parental immunity, or when antibodies have been produced by former vaccinations, as in the case of vaccinating by the wing-web method when birds have been vaccinated earlier by another

many outbreaks the nervous system is affected, chicks show a loss of balance, twisting of the neck, and paralysis

Adult birds Manifestations in adult birds may be few On occasion there may be some nervous disorders, along with coughing and rattling, but in most instances the birds look normal and there will be little mortality

In laying flocks egg production drops rapidly and abruptly Eggshell quality is affected, as in flocks affected with infectious bronchitis

Internal symptoms Post mortem observations usually are indecisive In some instances there may be mucus in the trachea, and the air sacs may be discolored and cloudy

Transmission

Newcastle disease virus particles are easily spread, the disease is highly contagious Methods of transmission are

(1) *Through the air* Coughing dislodges the virus from the respiratory tract whence it is easily airborne It travels quickly from bird to bird, and from house to house over short distances

(2) *On clothing, feed, trucks, etc* This category probably represents the major means of transfer of the virus to uninfected flocks and farms

(3) *No cleanup period on farm* Poultry operations that start chicks on a regular basis, resulting in several ages of birds on the farm at one time, have continuous problems, the older birds reinfect the younger Farms with an "all in, all-out" program of management break any cycle of infection when the premises are depopulated

(4) *Feed*

(5) *Wild birds, neighboring poultry, and predators*

Diagnosis

Many times a diagnosis may be made on the basis of physical observation Nervous disorders inflicting twisted necks and causing some young birds to be "tumblers" (head between legs causing the chicks to roll or tumble) are enough to warrant a fairly accurate diagnosis When the diagnosis becomes more difficult, certain laboratory techniques must be employed

(1) Hemagglutination test

(2) Virus isolation test Inasmuch as the virus disappears quickly from the bird, only birds in the early stages of the disease should be submitted to the laboratory for this test

(3) Hemagglutination inhibition (HI) test This test, being quantitative as well as qualitative, enables the technician to establish a titer

(4) Fluorescent antibody test

Treatment

There is no known treatment, although medication for secondary diseases probably will reduce some of the flock morbidity

Control

Effective control measures can be accomplished only by a rigid program of vaccination However, vaccines and vaccination procedures are so highly variable that

remains a disease of major importance. It is caused by a virus with a single serotype *Borreliota avium*.

Other Names

Diphtheritic roup
Dry pox
Pox
Skin canker
Wet pox

Diseases Confused with Fowl Pox

CRD
Infectious bronchitis
Laryngotracheitis
Newcastle disease
Roup

Symptoms

There are two forms of the disease, and the symptoms of each are different.

(1) *Cutaneous type (dry pox):* Wart-like scabs are found on the facial appendages—comb, wattles, eyes, and earlobes. There may be a loss of appetite, and general unthriftiness. Egg production drops, and fertility is impaired. In most instances little mortality occurs from the skin type of fowl pox.

(2) *Diphtheritic type (wet pox):* Yellowish, cankerous, and cheesy lesions appear on the internal wet surfaces of the mouth, tongue, esophagus, nasal passages, and sometimes the crop. When such lesions are removed, profuse bleeding occurs.

Breathing is hampered by the exudates, and the birds may suffocate. Egg production is retarded in laying birds; fertility is lowered. Mortality is much higher with the diphtheritic type than with the skin type.

Transmission

The skin acts as a barrier to the entrance of the virus; the skin must be broken for the organism to gain entrance. Transfer of the virus from bird to bird is relatively easy. Spread may be categorized:

(1) *Bird to bird:* The diphtheritic form spreads slowly from one bird to another in the pen. Most of the transmission is the result of birds picking, fighting, or scratching one another.

(2) *Mosquito:* The mosquito definitely is a means of spread. It punctures the lesions of affected birds, then transfers the virus to other birds when it "bites" them. Consequently, fowl pox is more prevalent during the mosquito season. In some instances the virus may enter the body of the mosquito and it will remain a carrier for several weeks.

Diagnosis

Pox lesions on the facial tissues of the bird are a definite indication of fowl pox; no other poultry disease produces these. But the diphtheritic type of the disease

method The wing web vaccines produce a severe reaction, they should not be used until birds are over 12 weeks of age

Give a second vaccination Complete "take" on the first vaccination at 14 to 21 days of age may not develop immunity in all chicks, because some may have parental immunity A second vaccination should be given when layer or breeder replacement birds are 7 or 8 weeks of age in order to vaccinate those not "taking" on the first Broilers usually are given the early vaccination only

Vaccine for 2nd vaccination Although most specialists suggest a stronger vaccine such as the B_1 type (Hitchner) for Newcastle vaccinations after the first, some recommend others The method of vaccination varies too, but individual bird application or the spray method are highly recommended

Vaccinating breeder birds As in the case of infectious bronchitis, parental immunity in the chicks should be uniform This means that the titers of the breeder females should be kept at a high level, and uniform, in order to have uniform parental immunity in the chicks Breeders should be vaccinated every 10 to 12 weeks while they are producing eggs

Velogenic Newcastle disease Recently there have been outbreaks of a highly virulent Newcastle disease in the United States and Canada Such outbreaks of a "hot" strain are characterized by respiratory symptoms, hemorrhagic conditions of the intestinal organs, high mortality, and a drasitc drop in egg production

Although vaccination programs commonly in use by most of the poultry industry are adequate for the usual mild variety of Newcastle disease, these programs will not give complete protection against velogenic strains of the virus Individually applied vaccines (intranasal, ocular, or intramuscular) may provide better immunity than mass vaccination Intramuscular type vaccines may be given at two weeks of age If there is evidence that velogenic Newcastle disease is in your area

(1) Consult the nearest diagnostic laboratory for advice and type of vaccine recommended

(2) Revaccinate all flocks every eight weeks

Changing from killed virus to live virus vaccine On occasion some poultrymen wish to change from a killed virus vaccine to a live virus vaccine Certain practices must be followed

(1) Do not administer the live virus vaccine for at least 3 to 4 weeks after the last killed virus vaccine was used

(2) It is best not to wait longer than three months after the last killed virus vaccine was given before giving the live virus vaccine

(3) Birds in egg production may be vaccinated with the live virus vaccine whether they have been previously vaccinated with killed virus vaccine or not There may be some respiratory disturbance and a slight drop in egg production, but nothing serious

FOWL POX

Fowl pox may be found in most poultry regions, but due to the use of vaccines it is not seen as often as formerly However, in certain areas of the world it still

Pigeon pox vaccine applied by feather-follicle method: This is the only acceptable method of application. Do not use the wing-web method. When day-old chicks are vaccinated, pull some down from the back of the chick, and brush the vaccine on the exposed area.

(3) *Modified pigeon pox vaccine:* Some vaccine manufacturers produce a pox vaccine made from a modified strain of pigeon pox. Being milder, it can be used for birds of any age, or for birds in egg production. Manufacturers claim this vaccine does not produce the diphtheritic form of the disease, and that it does not produce a viremia.

The vaccine is applied by puncturing the wing web.

Vaccinating broilers: If it becomes necessary to follow a vaccination program, the attenuated type of pigeon pox vaccine should be used. In hot climates, broilers may be vaccinated at one day of age by the wing-web method. Use one needle only. Or they may be vaccinated at 7 to 10 days of age. A mosquito-control program should be made a part of the preventive procedure.

LARYNGOTRACHEITIS

Laryngotracheitis is the result of infection by a specific virus, *Tarpeia avium.* Although the disease is found in every area of the globe, often it is sporadic in nature; some areas do not seem to be affected for long periods, then the disease appears. It is confined to chickens and pheasants.

Other Names

LT
Chicken influenza
Infectious tracheitis

Cause

This respiratory disease is one that spreads rapidly. The virus produces only a limited evidence in chicks under one month of age. It may vary in virulence, thus producing severe attacks in some outbreaks, mild in others. The virus has an incubating period of from six to ten days. Usually the disease runs its course in about 14 days, but in some cases it may linger on for a month.

Diseases Confused with Laryngotracheitis

Infectious bronchitis
Newcastle disease
CRD

External Symptoms

Laryngotracheitis produces a very severe respiratory disease. The birds cough and have difficulty breathing. The trachea becomes clogged, and the birds gasp trying to get air to their lungs. This gasping is so severe and common that it becomes a major criterion of the presence of the disease.

In young chickens there is an infection of the eye, causing pain. Tears flow freely; the eyes are watery.

is difficult to diagnose by visual means Several types of laboratory techniques are used to make a diagnosis

(1) *Bird transfer* A small amount of scab material from an infected bird is scratched into the surface of the comb of an uninfected bird About five days later typical pox scabs will arise

(2) *Virus isolation*

(3) *Inclusion bodies* Bollinger bodies are easily demonstrated in material collected from pox lesions during the early period of the disease

Treatment

Treatment generally is ineffective, although some drugs may be used to reduce the morbidity, particularly if secondary

Control

Control is readily accomplished by vaccination However, there are several types of vaccine, and several methods of application

(1) *Fowl pox vaccine* This is a virulent type of vaccine, it can be used only under specific conditions

(a) Birds must be five weeks of age, or older, because of its virulence

(b) Birds must not be under stress when it is administered

(c) Fowl pox vaccine may be used at the same time as the following vaccinations are given, but the pox vaccination must be conducted separately

Laryngotracheitis vaccination
Second Newcastle disease vaccination

How to apply the fowl pox vaccine Three methods are used to apply fowl pox vaccine

(a) Wing web puncture method

(b) Feather follicle method A few feathers should be pulled from the thigh of the bird, and the vaccine brushed on the bleeding follicle openings

(c) Spray method A variation in the feather follicle method is to spray the vaccine on the area from which the feathers have been pulled A specialized syringe, incorporating a spray, is used

Examination for "takes" About ten days after either of the above vaccinations, the birds should be examined If the vaccination has "taken" a definite pox scab will be obvious If there is no scab the birds should be revaccinated

(2) *Pigeon pox vaccine* This vaccine is milder than fowl pox vaccine Consequently, it may be used in cases where fowl pox vaccine produces a severe reaction, as in

(a) Day-old or very young chicks Parental immunity does not prevent immunity from vaccination because the area (feather follicles) where the vaccine is applied is not involved with a rapid flow of blood Few antibodies are at the site of vaccination

(b) Birds undergoing stress

(c) Older birds in egg production

cine available. It is a virulent type, and the vaccine is potent to the extent of being capable of reproducing the disease. It is administered by brushing the vaccine on the bursa of Fabricius (inside the upper lip of the vent). In approximately four days a cherry-red color develops, indicative of a "take."

Vaccine declared illegal in some areas. Because of the virulence of this vaccine, and because it is capable of spreading LT to uninfected farms and areas, it is not legally possible to use it in some sections.

Management and Eradication

Although it is probably possible to eliminate LT from the premises by the use of the attenuated vaccine, management should become a part of any eradication program. Isolation of affected flocks after vaccination, or even complete isolation of the farm, should be stressed as important.

Some Birds Remain as Carriers

After a natural outbreak, some birds remain as carriers for life. These few make up a reservoir of infection and are capable of spreading the disease to uninfected flocks.

Vaccinating Flocks Having LT

If the LT outbreak has been in existence for some time, vaccination is of no value. But if in the early stages, the affected pen should be vaccinated along with other birds on the farm. Start the vaccination with those birds farthest from the infected pen or house.

AVIAN ENCEPHALOMYELITIS

This disease is found in every area, but some isolated flocks may escape contamination. Although there is only slight economic loss in adult birds, avian encephalomyelitis may take on great proportions in young chicks.

Other Names

AE
Epidemic tremor

Diseases Confused with AE

Newcastle disease
Encephalomalacia (Due to a vitamin E deficiency)

Symptoms in Young Birds

The disease is one that affects young chicks between 6 and 21 days of age. They show nervous symptoms of varying proportions, including paralysis. The body quivers, and this symptom is especially noticeable when the chick is held in the palm of the hand. Many chicks lie on their sides, and cannot motivate themselves. Mortality is high, death results not from the disease itself but because the chicks cannot get to feed or water. Birds over four weeks of age seldom show evidence of AE.

Internal Symptoms

The trachea is filled with an exudate, loosely attached to the tracheal lining In most cases it may be removed easily This makes a differentiating factor when it is necessary to determine the type of disease infecting the flock There is severe hemorrhaging, and blood is coughed up as the birds endeavor to breathe

Mortality

As the disease is of varying severity, death losses fluctuate from flock to flock, and from year to year In some cases as many as 30% of the birds will succumb, in others, the mortality may be light Age of the bird does not seem to be a contributing factor Recent outbreaks seem to be less virulent than those occurring several years ago

Transmission

The disease spreads rapidly from bird to bird Modes of spread are

(1) *By air* Although airborne for short distances, as in a pen of birds, seemingly the organism cannot be carried in the air over long dis tances Thus, this is *not a means of transferral from farm to farm,* and it is doubtful if the virus will be carried by the air to adjacent poultry buildings on the same farm

(2) *By people, trucks, birds, rodents, etc* Mechanical means of dissemina tion of the virus is, no doubt, the major means of spread

Diagnosis

For accuracy of diagnosis the services of the laboratory must be employed Tests used in establishing identity of the virus are

(1) *Challenge* Inoculate suspicious material into the sinuses If the disease is present there will be a discharge and swelling in 3 to 5 days

(2) *Virus isolation (and identification)* The virus is grown on egg embryos Only birds in the early stages of the disease should be sent to the laboratory for this test

(3) *Serum neutralization (SN) test* This test is of limited value as it takes three weeks

Control

Control is by vaccination There are two main types of vaccines

(1) *Modified LT vaccine* This vaccine is not capable of producing the dis ease in vaccinated birds, consequently it will not cause any spread The immunity is as good as that of any other vaccine It can be ad ministered to young birds and to birds in egg production with only slightly noticeable effects Parental immunity may affect the "take" in birds under 21 days of age

How to vaccinate The vaccine should be dropped onto the open eye ball Some immunity will be developed in 2 days, maximum im munity will be reached in 6 days Vaccinate at 10 to 15 weeks of age Repeat if before ten weeks

(2) *Cloacal type vaccine* For many years, and until the modified type of vaccine appeared on the market, this was the recognized and only vac

most instances failures have been caused by vaccine of poor quality due to improper storage, or by inadequate methods of vaccination.

AE parental immunity is stronger than is the case with most diseases, and lasts for a longer period. Chicks to be used as breeders should not be vaccinated before eight weeks of age.

Check the immunity prior to using hatching eggs: Several of the first fertile eggs laid by the flock should be submitted to a laboratory for an immunity test. This will show whether the vaccination was adequate. If inadequate, the flock must be revaccinated immediately. Three weeks must elapse after the revaccination before hatching eggs are saved. Any eggs set during this three-week period will be AE-contaminated and will infect the resultant chicks.

Types of vaccine: AE standard vaccines have been used for some time, and have been the basic ones involved. But recently a new one has been marketed. Details of these two types are as follows:

(1) *Live-virus vaccine:* The vaccine is very virulent, but this is no disadvantage. It may be frozen. It is to be given in the drinking water, or may be dropped into the eye of the bird. In the latter case, only about 5% of the birds need be vaccinated; other birds in the flock will acquire the disease from the vaccinated ones, and develop an immunity.

(2) *Killed-virus vaccine:* The live-virus vaccine usually will cause a drop in egg production if administered to laying birds. A killed-virus vaccine may be used for such flocks.

Determine status of vaccinated birds: About four weeks after vaccination, birds should be submitted to the laboratory for an evaluation of their immunity by checking for virus-neutralizing antibodies. If they are not present, the flock should be revaccinated.

LYMPHOID LEUKOSIS

Diseases in this classification are numerous, and for years have caused great economic losses to the poultry industry.

Other Names

LL
Big liver disease

Disease Confused with LL

Marek's disease

Cause

Lymphoid leukosis is the result of infection from one or more viruses, perhaps 3 or 4. Each may be responsible for the various forms of the disease:

Lymphoid leukosis
Erythroid leukosis
Myeloid leukosis
Osteopetrosis
Others

Symptoms in Adult Birds

In most outbreaks in adult flocks there will be no noticeable symptoms in the birds However, egg production often is affected, as exemplified by a drop in the number of eggs produced by the flock each day

Transmission

The disease is transmitted by two methods

(1) *Fecal transfer of the virus* As the virus multiplies in the intestinal tract, the fecal material offers one direct method of transfer Consequently complete eradication is impractical Contaminated water and feed implement the transmission from bird to bird in the pen Similarly, transfer of fecal material to uninfected pens will cause an outbreak Such a virus will live outside the body of the bird for several days Virus particles begin to occur about three weeks after the birds have been infected

(2) *Transmission through the hatching egg* The virus is shed by the infected breeder hen through the hatching egg to the newly hatched chick Unfortunately, because infection in the breeder flock may go unnoticed, the first indication of trouble comes from the customer who purchases the chicks As the infected eggs were laid at least three weeks prior to hatching, the disease has almost always run its course in the breeders by the time chick infection is noticed in the field

Eggs in incubators must be destroyed It takes but a few days for the infected breeder hen to recover, but because all birds in the flock do not have AE at the same time, most flocks will lay eggs containing the virus for a period of about three weeks This means that under most conditions all eggs in the incubators from the infected flock must be destroyed There may be other infected chicks in the field at the time the first customer notifies the hatchery of the infection Some program of handling these customer cases should be established

Diagnosis

Most cases of AE can be diagnosed in the poultry house, but not all Suspect chicks should be submitted to a laboratory The following tests are used for the identification of AE

(1) *Histopathology* Brain tissues are fixed, sliced thin, stained, and examined under a microscope
(2) Inoculation of uninfected chicks

Control

No drug will alleviate the condition once there has been an active outbreak in the flock Therefore, control of the disease by vaccination of growing birds to be used as breeders is the only means of safety from AE Be sure to vaccinate the males

When to vaccinate Growing birds to be used for breeders should be vaccinated after 8 weeks of age and 3 weeks before the first eggs are laid by the pullets However, there have been many failures with AE vaccination In

susceptibility, flocks do not respond similarly to improved husbandry practices Isolation and general disease-preventive methods of management cannot give assurance that the incidence of the disease will be lessened. Because lymphoid leukosis is egg-transmitted, and because there is no positive means of eliminating infection from the breeder birds, at least a few infected chicks hatch, and these soon transmit the virus to others

MAREK'S DISEASE

One phase of the leukosis complex is known as Marek's disease For years scientists have been trying to isolate the organisms responsible for this disease and to develop a means of control Only in the last few years have their endeavors resulted in some degree of satisfaction

Other Names

- MD
- Galloping leukosis
- Egg paralysis
- Ocular paralysis
- Range paralysis
- Skin leukosis
- Visceral leukosis

Disease Confused with Marek's Disease

- Lymphoid leukosis

Cause

Marek's disease is a neural disease caused by a herpes virus There probably are several strains, each resulting in a different type of infection, or location of the virus in the bird. Seemingly, the virus is present in every bird the world over, but there are many causes for the variations in the severity of the disease Birds may become infected early in life, and undoubtedly remain infected until death. Not all infected birds show the presence of the disease, but the lack of visible evidence does not mean the bird does not harbor the virus Tumor incidence is not the only indication of the presence of the virus In fact, some other areas, as cells lining the feather follicles, may be a more important area of infection. Neither is the incidence of the disease a reliable index of the amount of infection in the bird; the virus does not seem to localize in the tumors

Antibodies appear along with the herpes virus, and may have great longevity. The preponderance of one or the other probably is responsible for a part of the variation in the degree of morbidity and mortality. But eventually some lesions enlarge and cause death.

Transmission

Bird-to-bird transmission is the main method, but many of the exact processes are not known Some established variations are as follows:

Airborne: MD has a unique method of air transmission, much different from that of other airborne respiratory infections With MD the virus localizes in the feather follicles and is sluffed through the dander and feather particles In fine form it floats in the air and is inhaled by the birds

Mechanical When feather dust and dander settle on clothing, feed bags, equipment, etc., the virus is easily transmitted to other poultry houses and to poultry-producing areas

Bursa of Fabricius involved This gland seems to be the origin and seat of infection Here the viruses localize and develop The bursa may get as large as a golf ball As the bird approaches sexual maturity these viruses find their way to other organs and structures by way of the bloodstream, particularly the liver, kidneys and spleen

Symptoms

Most forms of leukosis occur in older or laying birds, at least mortality is seldom a factor in young birds In the early stages of the disease, the birds seem normal, but eventually a small percentage of them begin to develop tumors As these increase in size, or manifest themselves, the internal organs show the effect Particularly important in this change is the development of a big liver The ovary is not affected With one form of the disease, *osteopetrosis*, the shanks may become enlarged, and the legs bowed

Those birds severely affected with some form of lymphoid leukosis deteriorate rapidly Their physiological well being soon drops to a level below that necessary to sustain egg production

Lymphoid leukosis seldom reaches an acute stage of mortality, daily death losses remain low but continue over a long period In contrast to Marek's disease, birds do not recover

Transmission

This disease is transmitted to the chick through the hatching egg, this is, no doubt, the greatest initial method of transmission

In infected breeder hens antibody production is slow and poor Furthermore, not all the eggs laid are infected, and not all chicks hatched from infected eggs carry the virus or viruses But only a few infected chicks are necessary to transmit the disease to other chicks in the pen Most of this transmission occurs in chicks under four weeks of age Even though most of the chicks in the pen are probably infected, only a portion will develop tumors

Diagnosis

Although many of the manifestations are visible, laboratory tests may be instrumental in an accurate diagnosis

RIF test RIF stands for 'Resistant Inducing Factor" It is used to determine the existence of the virus of lymphoid leukosis Marek's disease is RIF negative, lymphoid leukosis is RIF positive

COFAL serological test The "Complement Fixation Avian Leukosis" test is used to differentiate between lymphoid leukosis and Marek's disease The test is based on the fact that an antigen, when mixed with antibodies, produces a reaction (clumping) In the RIF positive type of virus of lymphoid leukosis there is a common antigen effective against the lymphoid leukosis virus (positive) This particular antigen is, however, negative to the virus producing Marek's disease

Tests not practical for diagnosis The above two tests take a great deal of time to complete, they are not practical for commercial diagnosis

Treatment and Control

There is no known treatment Methods used to prevent outbreaks of the various forms of the disease have been highly ineffective Because of the variations in

shown to be tumor-forming, nor will it spread from bird to bird, which is a definite advantage.

Freeze-dried HVT vaccine: Such a vaccine is being offered for sale in some countries.

Other Vaccines and Methods

Scientists in various parts of the world have developed several other viral agents for the production of vaccines. Most of these however, have been developed from strains of virus causing MD in chickens. When chicks are vaccinated with these vaccines, the virus may be transmitted to other birds, although the originators have weakened the organisms to prevent as much spread as possible.

Some broiler producers are injecting a mixture of turkey blood, diluent, and antibiotics subcutaneously into the nape of the neck of chicks.

Management Programs

Many endeavors have been made to associate certain management practices in the poultry house with lowering the incidence of Marek's disease. Some of these, with a brief statement of their effectiveness are as follows:

(1) *Coccidiosis control:* There seems to be no correlation between the incidence of coccidiosis and MD even in the face of a seeming association in some field cases. Coccidia are not carriers.

(2) *Reusing old litter:* Probably ineffective in controlling Marek's disease unless the old litter contains the MD virus.

(3) *Cleaning the premises:* The disease is too easily spread to provide sterility to MD even with a superior method of cleaning the buildings and premises.

(4) *Bird exposure:* Exposure of young chicks to infected adult birds offers little promise of reducing the incidence of MD.

Genetics and Marek's Disease

The geneticist has been active in trying to develop strains of birds with a high degree of resistance to Marek's disease and lymphoid leukosis. In the early days, the "survival of the fittest" theory was used, where infected birds were raised with growing chickens. Those birds surviving leukosis outbreaks were used as breeding stock, supposedly with a higher degree of resistance. But this procedure offered few possibilities; although some strains developed a higher initial resistance, many soon showed a reversal and became nonresistant.

A more recent genetic procedure has been to develop "hot strains" of leukotic agents, then inoculate chicks of various ages with these, and either breed from the survivors or their sibs (brothers of sisters).

GUMBORO DISEASE

Gumboro disease is a relatively new disease found only in chickens. Caused by a virus, it is immunologically related to infectious bronchitis.

Other Names

IBA (Infectious Bursal Agent)

Avian nephrosis (nephritis): This is actually a misnomer, as the kidneys are not the primary seat of infection.

Infectious bursal disease

Other means of spread Undoubtedly there are means of spread other than through material from the feather follicles Certain beetles have been identified as carriers

MD virus not embryo transmitted Although some forms of MD have been associated with egg transmission, from a practical standpoint it may be stated that this method is of very little importance in the transmission of the disease

Diagnosis

Marek's disease is RIF negative, and the test is used to differentiate between MD and lymphoid leukosis, which is RIF positive

There are several tests used in the laboratory to establish the identity of MD However, the cost of performing them is still beyond the realm of commercial practicability, and very few laboratories are properly equipped to complete the tests

Control

There are now several vaccines used in the control of Marek's disease

Herpes virus, turkey origin, vaccine The turkey is susceptible to Marek's disease, but the causative virus is not the same strain as that causing the disease in chickens But both strains are herpes like, and bear a close similarity A vaccine has been developed using the turkey virus as its origin When injected into young chicks it has the ability to stimulate the bird's resistance to the production of tumors or other lesions of Marek's disease The herpes turkey virus (HVT) will produce a viremia in the chicken, and such birds will not develop the symptoms of Marek's disease common to the chicken

Another point of interest in this complex disease is that the chicken virus will not produce Marek's in the turkey

The fact that the chicken virus may be isolated from chickens vaccinated with the turkey type virus would seem to indicate that the turkey virus in such vaccinated birds is not producing immunity to the chicken type of the disease, but is only suppressing the growth of the tumors produced by the chicken virus

The strain of turkey virus (FC 126) showing the above characteristics was first isolated in 1969 at the USDA Regional Laboratory at East Lansing, Michigan, and is used predominately to develop the vaccines being produced by several vaccine manufacturers The turkey virus is propagated in embryonic duck or chicken cell cultures, the vaccine is standardized, then preserved at very low temperatures of 120° to 135°F in liquid nitrogen or nitrogen gas It must be thawed when needed, mixed with the diluent, and used to vaccinate the chicks when they are one day of age The thawed and mixed vaccine must be used quickly, two hours is the maximum time allowance after thawing The vaccine is injected subcutaneously in the nape of the neck but may be administered intra abdominally Every chick must be vaccinated Although the procedures for handling the vaccine and vaccinating the chicks are complicated, millions of birds are now being injected

The HVT vaccine has no adverse effects in chickens It has not been

ministered when the chicks are about one week of age Vaccination should be used only on farms where there has been a history of high incidence of the disease

MYCOPLASMA GALLISEPTICUM

Air sac disease is known everywhere, and is particularly important to the broiler grower, inasmuch as any infection in the air sacs is cause for condemning the dressed bird as unsuitable for human consumption

Other Names

MG
Air-sac disease
Chronic respiratory disease (CRD)
PPLO (pleuropneumonia like organism)
Respiratory mycoplasmosis

Cause

An organism intermediate between a virus and a bacterium, the PPLO is exceptionally small, and is the cause of the disease Over 15 serotypes have been discovered The one to which this disease is attributable is known as S 6 serotype It has been found in the chicken, turkey, and duck PPLO is a stress disease because the organism seems to remain dormant in many flocks, but when birds are stressed it becomes active

Diseases Confused with MG

Laryngotracheitis
Infectious bronchitis
Newcastle disease
Fowl cholera
Mycoplasma synoviae (infectious synovitis)

Symptoms in Young Birds

PPLO is a respiratory disease, affecting the entire respiratory tract, particularly the air sacs, where it localizes All the air sacs may become involved, are cloudy in appearance, and filled with mucus In the latter stages of the disease this mucus develops a yellow color and a cheesy consistency Similar exudates may encircle the heart and heart sac

PPLO in itself is not a killer, in fact, even morbidity is not great, but an outbreak is quickly followed by many secondary infections, and it is these that do the damage Thus, visible identification of PPLO is often confused by symptoms of the secondary invaders

In young chicks there is a rattling, sneezing, and sniffling, all indicative of the respiratory difficulty If complicated by other similar respiratory diseases these symptoms are accentuated In severe cases mortality may run as high as 30%

Symptoms in Mature Birds

Visible evidence of the disease in adult birds may go unnoticed Occasionally the birds will appear depressed and inactive There may be a definite diarrhea

Cause

The disease is caused by a specific virus, and although the virulence is highly variable, there is but one serotype It is not caused by the bronchitis virus

Diseases Confused with Gumboro Disease

Blue comb disease (where kidney damage is evident)
Avian encephalomyelitis

Symptoms

The disease seems confined to growing birds Inception is rapid between 15 and 60 days of age, and recovery will take from 1 to 3 weeks

Birds are listless, nervous, sleepy, dehydrated, and have a whitish diarrhea The vents seem irritated, and birds continue to pick at their own vents

The bursa of Fabricius plays an important part in the disease The gland is the productive area of IBA antibodies and swells during the course of infection, only to return to normal after the disease subsides

Mortality is variable Although most flocks of chicks harbor the virus or its antibody, most cases of the disease are so slight as to go unnoticed Only on occasion are there severe outbreaks, with mortality running as high as 30% Mortality increases with age up to ten weeks

Transmission

The virus is very stable, and is capable of remaining viable outside the host for several months Unclean poultry houses and poultry equipment are definite sources of infection

Diagnosis

Visible symptoms are not such as to warrant a positive diagnosis by observation alone Birds must be sent to the laboratory Several tests are used to arrive at a decision

(1) *Virus isolation (and identification)* The identification is made by infecting egg embryos IBA negative eggs must be used, for the virus will not survive in the presence of antibodies in the egg
(2) *Serum neutralization test*
(3) *Chick inoculation test* The bursa of noninfected birds will enlarge appreciatively a few days after inoculation with infective material

Treatment

Treatment with drugs and antibiotics has been of little value except for some possible reduction of morbidity from secondary infections

Control

Control revolves around two practices, management and vaccination

(1) *Management* Clean premises and an "all in, all-out" program will be helpful in breaking any cycle of infection, although the procedure is less effective than with most diseases Older birds on the premises are carriers, and continually remain a source of infection
(2) *Vaccination* A live virus type of vaccine is available for use where entire flocks are involved The vaccine is water type, and should be ad

(1) *Testing the breeder flock:* The test is similar to the pullorum whole-blood test except that blood serum is used for conducting the MG test instead of whole blood, as for the pullorum test.

(a) Bleed the bird from the wing and collect the blood in a small glass test tube. Place the tube in a horizontal position and allow the serum to separate. At 70°F (21.1°C) this will require 1.5 to 2 hours. Then refrigerate at 45°F (7.2°C). Do not freeze.

(b) When ready to make the test, remove the test tubes from the refrigerated compartment and warm them to room temperature. Then place a drop of MG antigen on the testing plate.

(c) After running positive-serum and negative-serum tests on the antigen to be used, place a drop of the bird's serum on the antigen, and mix. If the bird is positive (infected) a clumping will appear within two minutes. If the mixture is clear, the bird does not carry antibodies, and is not an infected carrier.

There also is a laboratory tube test for detecting infected birds.

(2) *Testing day-old chicks:* Since the breeder flock is blood-tested only every three weeks during the laying season, there is a possibility that it could "break" with the disease between tests. As assurance that the chicks are not affected, culls or dead embryos should be blood-tested at hatching time. Test about 1% of each group of chicks, and test every hatch.

First test the antigen, using negative and positive serum. Then collect blood from the neck, and complete the plate test as outlined for breeding birds.

(3) *Checking for lesions in day-old chicks:* PPLO lesions are to be found in the thoracic air sacs of infected day-old chicks. Pipped embryos should be examined at every hatch for any evidence of lesions. About 20 chicks from each group should be examined.

Mycoplasma Gallisepticum PPLO S-6 Negative Program

Following is a brief outline of the procedures necessary to carry out this program:

(1) *General*

Assign an individual to police the program.
Strict sanitation and isolation are mandatory.
Decentralize facilities.
Employees must shower before going on the premises.
Brood, grow, and lay the birds in the same house.

(2) *For breeder flocks*

Secure MG S-6 negative chicks only.
Allow 100 ft (30.5 m) between all poultry buildings.
Use concrete floors in all buildings.
Thoroughly clean, wash, and disinfect the buildings.
Screen windows with small-mesh poultry netting to keep out birds and rodents.
Use new, clean, and dry litter.
All persons must shower before entering the poultry house area.
Use a disinfectant pan at the entrance to each house.

during the intestinal phase of the disease Egg production takes a material drop Mortality in adult birds usually is low

Transmission

There are several methods whereby the *Mycoplasma gallisepticum*, S 6 serotype organism may be transmitted

(1) *Through the hatching egg* This is the major means of spread, the virus passes from one generation to the next Transmission is not uniform, for it is greater during the period of active infection in the adult birds, then subsides But only a few organisms in a few infected chicks are necessary to cause the disease to spread to practically all young chicks in the flock

(2) *Through the air* The organisms may move short distances by way of the air This is enough to cause infection of birds within a pen, but probably has little consequence in the transfer from house to house

(3) *On clothing, feed bags, feed, poultry equipment and trucks* Personnel represent the important carriers Probably 60% of cross-contamination between houses is the result of the organisms transported by people

Diagnosis

CRD may be fairly accurately diagnosed by the coughing and sniffling involved Laboratory tests used for diagnostic determination are

(1) *Rapid serum plate agglutination test*

(2) *Embryonic examination* Embryos infected with MG have lesions in the air sacs A few cull chicks or pipped embryos should be examined at hatching time Positive evidence of infection is conclusive proof that the parents have MG infection

Treatment

Tylosin is an antibiotic specific for the treatment of birds infected with MG Streptomycin also may be used

Control

Control can be by vaccination, controlled exposure, or eradication However, eradication seems to have become the accepted method Medication can only be considered temporary

Eradication is built around complete curtailment of embryo transmission This means that infected dams must be removed as a source of infection Unlike pullorum disease, MG is difficult First, it is so contagious that one or two infected birds in the pen will infect practically all others in a very short time Second, an infected bird continues to be a carrier, and *sluffs virus through the* egg Thus, if any infected birds are found in the breeding pen, all the birds in the pen must be eliminated as a source of hatching eggs There is no such thing as testing and retesting, as with pullorum Furthermore, breeder flocks may remain clean (no infected birds) for long periods, but suddenly "break" with infection for no obvious reason

Tests Involved with PPLO Elimination

There are several methods of testing involved in eliminating the infected breeder flocks and in testing the day-old chicks to determine their disease status

Symptoms

Actually, MS is a respiratory disease; but seldom is the respiratory tract involved with sickness or death, though air-sac infection is noticed when broilers are processed. However, the organisms soon locate in the synovial fluids of the hock and joints of the footpads. These two areas become swollen and inflamed. In some severe cases, the wing joints may become affected.

In most instances this is a disease of young and growing chickens between six and 14 weeks of age, but it occasionally attacks older birds. There is a loss of appetite and wieght. Birds are lame when the joints become inflamed, and sit on their hocks.

Morbidity, rather than mortality, is a problem; seldom is there a very high death loss; in older birds, egg production may drop 20 or 30%.

Transmission

There are several known means of transmission, and probably others that are not clearly understood.

(1) *Through the hatching egg:* The disease is definitely egg-transmitted, and although the percentage of infected eggs is very low, these will give rise to enough infected chicks so that eventually a high percentage of the flock becomes infected. After infection, breeders will sluff *M. synoviae* for as long as 14 to 40 days.

(2) *Through the air:* The organisms are easily transmitted from bird to bird within the pen by air, but probably not from house to house.

(3) *On clothing, trucks, equipment, etc.:* Mechanical means of transfer are of major importance in transporting the organisms over long distances.

Diagnosis

Swelling of the joints of the hock and footpad are an exemplification of MS, but not necessarily a diagnosis; there are too many diseases that produce similar conditions.

Birds should be submitted to the laboratory where two tests may be conducted:

(1) *Plate agglutination test:* This is a test similar to the agglutination test for pullorum disease and MG. Blood serum is mixed with MS antigen. As it is an antibody test, serum drawn from birds that have had the disease will clump with the antigen. This also may be conducted in the poultry house.

Note: There is some cross-agglutination between *M. gallisepticum* and *M. synoviae* organisms. *M. gallisepticum* antibodies may cross-agglutinate with MS antigen. The opposite is not true.

(2) *Bird inoculation:* Material is drawn from suspected hocks, ground, strained, and injected into the joint of the footpads of four-week-old chicks. If the donor is infected with *M. synoviae* or *M. gallisepticum*, there will be a definite swelling of the footpads of the recipient chicks in about a week. Blood-test to differentiate MS from MG.

Treatment

Some broad-spectrum antibiotics are of value.

(1) *Chlortetracycline:* Add to the feed at the rate of 200 gm per ton (2,000 lb) for about a week.

Important: Do not feed to laying chickens.

Use only approved vaccines that are specific pathogen free (SPF)
Birds must be blood tested, preferably by a state or regulatory agency
The test is conducted like the plate test or the tube test for pullorum disease
Test 5% of the birds in each pen when the chicks are eight weeks of age, and thereafter make another test every four weeks until the birds reach sexual maturity
Carefully check the antigen used for all tests
Just prior to egg production, test all the birds using the laboratory tube test, thereafter test 5% of the birds every 3 weeks
Incinerate all dead birds
Fumigate all hatching eggs in the poultry house immediately after the eggs are laid

(3) *For hatching eggs*
Gather eggs in clean containers or flats
Use clean egg transportation vehicles
Process only MG S 6 negative eggs

(4) *For hatcheries*
Set only S 6 negative eggs
Hatch only S 6 negative chicks
Use only new, clean chick boxes and pads
Fumigate everything regularly
Employees must shower when entering the hatchery building

(5) *For chick deliveries*
Truck drivers must shower and wear clean clothes
All delivery vehicles must be thoroughly cleaned, disinfected, and fumigated before loading the chicks

MYCOPLASMA SYNOVIAE

A prevalent disease for many years, the recent identification of the causative organism has brought new understanding of the intricacies behind MS

Other Names

MS
Silent air-sac disease
Infectious arthritis
Infectious synovitis

Cause

The disease is due to an organism similar to that causing *Mycoplasma gallisepticum* It is between a virus and a bacterium, specifically called *Mycoplasma synoviae*

Diseases Confused with MS

Slipped tendon
Staphylococcus arthritis
Coccidiosis (when intestinal hemorrhaging is involved)
Fowl typhoid

Cause

Coccidia have specific hosts; and each species produces its own type of coccidiosis. The coccidia that inhabit the chicken are all in the genus *Eimeria*.

Coccidiosis is spread by unicellular bodies known as *oocysts*. These are shed in the droppings, but are not infectious. They first must be *sporulated*, a process that takes place when conditions of air, temperature, and moisture are opportune. This sporulation, therefore, occurs outside the body, requiring two to four days. The sporulated oocyst is eaten by the chicken and finds its way to the intestinal tract, where a series of divisions and multiplications take place. Eventually more oocysts are produced, most of which again are expelled from the body in the fecal material, and the life cycle is complete. The time from ingestion to expulsion varies between four and seven days, depending on the species.

Coccidia, being parasitic, live in the epithelial tissues of the intestinal tract, and there they inflict their damage. Usually one oocyst in the intestinal tract can destroy only a few cells. Therefore, the extent of destruction of the intestinal wall is closely related to the number of oocysts present. But when the disease is at its height there will be millions of oocysts, although not all will be sporulated. Continued ingestion of the sporulated oocysts means that more cell tissue is destroyed.

Diseases Confused with Coccidiosis

- Enteritis
- Fowl cholera
- Fowl typhoid
- Hemorrhagic disease
- Paratyphoid
- Pullorum disease

External Symptoms

Symptoms include bloody droppings, ruffled feathers, paleness, loss of appetite, lowered growth, poor feed conversion, drop in egg production, diarrhea, and many other manifestations. Most of the external symptoms are the result of general disability due to the destruction of the lining of the intestinal tract; this in turn prevents the transfer of food material from the intestines to the bloodstream. In many cases hemorrhaging of the intestinal lining occurs, and blood in many forms is deposited with the droppings.

Internal Symptoms

Internal symptoms usually are confined to the intestinal tract, including the ceca. Inflammation, hemorrhages, lesions, mucus, and exudates are all indicative of coccidiosis, but most species produce specific internal symptoms. These are outlined in Table 41.1.

Transmission

The only method of transmission is for the bird to consume *sporulated oocysts*. Within the pen this goes on constantly because birds have access to the droppings. But the transfer from house to house and farm to farm is by mechanical means. In the active stage of the disease, millions of oocysts are contained in each teaspoonful of fecal material. These are easily transferred to a new location by shoes, feed trucks, crates, pets, rodents, and moving equipment. Once sporulated, the oocysts soon cause an outbreak of coccidiosis in the new premises.

(2) *Oxytetracycline* Add to the feed at the rate of 200 gm per ton (2,000 lb) for about a week

Resume drug treatment if disease does not subside The treatment may be continued longer if the disease is not brought under control by the first treatment

(3) *Individual injections* Serious outbreaks in adult birds may be treated by injecting oxytetracycline or erythromycin Individual treatment in this manner is not practical with broilers because of the labor involved and the stress of handling

Control

Two methods are available for controlling the disease

(1) *Eradication* Eradication is possible if the breeders can be kept free of the causative organism The following test is to be completed

Serum agglutination test This test is identical with the test used for identifying carriers of *M gallisepticum*, except that an antigen specific for *M synoviae* is used However, there have been difficulties in reading the reaction on the testing plate The clumping is not as well-defined, and there is some cross agglutination with other organisms and blood properties On a flock basis, the test should give a means of determining whether there are, or are not, reactor birds The breeder flock should be sample tested every four weeks The test should not be used to identify individual carriers

(2) *Heat treatment of hatching eggs* A procedure has been established for heating hatching eggs before they are placed in the incubator The eggs are heated to 115°F (46 1°C) At this temperature the Mycoplasma are destroyed, but hatchability is affected only slightly

How to do it Full details of this procedure are given in Chapter 8 These directions must be followed very carefully if the program is to be successful

Importance of heat treatment As it seems difficult to identify and remove infected birds from the breeder flock by the agglutination test, heat treatment offers a substitute method, that is, heating the eggs prevents transmission of *M synoviae* organisms through the hatching egg to the chick The heat treatment is especially important to the primary breeder of broiler type stock Such a genetic breeder can offer breeder replacement chicks for sale that are free of the organism, and if the purchaser of such chicks uses diligent care and isolation during the growing program he can be pretty well assured that he will be able to produce broiler chicks that are MS free, or substantially so

The program of heat treatment has not been used as much by the primary breeder of egg type stock as by the breeder of meat type birds

COCCIDIOSIS

Coccidiosis is a term used to identify the diseases produced by a group of protozoan (parasitic) organisms in the class "Coccidia" There are hundreds of types, but only nine are important to the raiser of chickens

has made the use of coccidiostats difficult. Furthermore, some species of Eimeria have become resistant to certain coccidiostatic drugs, mainly those that have been used consistently for treating several generations of birds.

Most outbreaks of coccidiosis are produced by three Eimeria:

(1) *E. tenella*
(2) *E. necatrix*
(3) *E. acervulina*

The others account for less than 15% of the attacks, and usually involve only slight economic loss. Any good coccidiostat should be specific for the above three Eimeria.

Properties of good coccidiostats:

(1) Prevent infection from as many species of Eimeria as possible.
(2) Make it possible to dilute the dosage so as to develop natural immunity in breeder replacement chicks.
(3) Do not interfere with reproduction (egg production and fertility).
(4) Are not electrostatic or hygroscopic
(5) Should be nontoxic, palatable and stable
(6) Should be economically acceptable.

Chemicals used as coccidiostats: Several chemicals, many of them unassociated, have been and are used as coccidiostats. (See Chapter 40.) Those commonly used today are:

Amprol® (amprolium)
Amprol plus® (plus ethopabate)
bifuran® (not for broilers)
Bonaid® (buquinolate)
Coban® (not for layers)
Coyden® (clopidol)
Deccox® (decoquinate)
Nicarbazin
Nidrafur® (nihydrazone)
Polystat-3, Unistat®
Statyl® (nequinate)
Sulfonamides
Zoalene

Important features of each: A discussion of the value of each of these drugs would take too much space here. For details refer to technical books on the subject, or write directly to the manufacturer.

Developing Immunity to Coccidiosis

Under natural outbreaks, chickens with coccidiosis develop an immunity to the Eimeria species that caused the disease. This immunity does not last a lifetime; but as the bird is continually consuming more sporulated oocysts, they produce continued immunity throughout the life of the bird.

Immunity may be developed artificially in the bird without the stress of its encounter during an attack of acute coccidiosis. This process is made possible by the fact that if the number of oocysts in the intestinal tract is kept at a low level there will be no danger of serious coccidiosis, yet the number will be adequate to enable the bird to build an immunity.

TABLE 41.1

CHARACTERISTICS OF COCCIDIA SPECIES

Species Common name	External Symptoms	Intestinal Area Most Affected	Mortality	Morbidity
E. necatrix Intestinal coccidiosis	Diarrhea Bloody droppings Ruffled feathers Weight loss	Whitish lesions on upper third of small intestine	Heavy	Heavy
E. tenella Cecal coccidiosis	Bloody droppings Drop in feed Droopy Fewer eggs	Hemorrhagic ceca	Heavy	Heavy
E. acervulina Layer coccidiosis	Diarrhea Fewer eggs Drop in feed Weight loss	Upper half of small intestine	Light	Medium
E. brunetti Intestinal coccidiosis	Diarrhea Emaciation	Lower half of small intestine ceca, and cloaca	Light	Light
E. maxima Intestinal coccidiosis	Diarrhea Bloody droppings Drop in feed Pale color	Middle and lower sections of small intestine	Light	Medium
E. mivati Intestinal coccidiosis	Fewer eggs Ruffled feathers	Lower half of small intestine	Light	Heavy
E. hagani	Diarrhea Drop in feed	Upper half of small intestine	Light	Light
E. praecox	Diarrhea Weight loss	Upper third of small intestine	Light	Light
E. mitis	Diarrhea	Entire small intestine	Light	Light

Diagnosis

Appearance of the bird, along with intestinal lesions, may suffice for a diagnosis of most outbreaks. However, many symptoms are similar to those produced by other diseases. A laboratory diagnosis then is necessary.

Scrapings are made of the infected area of the digestive tract, and a microscopic examination is made for the presence of coccidia.

Control

Coccidiosis is far more easily prevented than treated. Certain chemicals, known as coccidiostats, suppress or upset the life cycle of the protozoan. The coccidiostats usually are added to the feed at a designated percentage. However, all such chemicals do not have equal ability to suppress all of the Eimeria species. Such drugs reduce or eliminate the shedding of oocysts in the droppings, thus reducing or preventing oocyst contamination of the poultry house floor. Some drugs are so specific for certain Eimeria that they completely suppress them, yet have little effect on others. Because there are nine types of coccidia, a person might be using a drug against one type while an outbreak is arising from another type. This

(6) Do not feed a coccidiostat when the CocciVac program is being followed. A coccidiostat given at this time will only suppress oocyst formation and the development of immunity.
(7) Be ready to treat for a coccidiosis outbreak: The CocciVac program is a quantitative one, in which immunity will be built up when the population of oocysts in the intestinal tract is small. If, however, too many sporulated oocysts are consumed when the bird eats the litter, incidence of coccidiosis of varying proportions may arise. Some small degree of coccidiosis is necessary to be sure that immunity is developing, but if coccidiosis is excessive, the flock must be treated.
(8) Add vitamins A and K to the feed: Vitamin A helps repair epithelial tissue; vitamin K helps prevent intestinal bleeding.

Treatment

In spite of many excellent programs and chemicals for the control of coccidiosis, there are many outbreaks of the disease. *Treatment*, therefore, becomes a necessary part of any control program. Several drugs are used; some are to be given in the feed; some in the water:
(1) Sulfaquinoxaline (do not feed to layers nor to birds within five days of slaughter.)
(2) Sulfamethazine
(3) Esb_3 (for use in the drinking water)
(4) Agribon
(5) SEZ
(6) Amprolium (soluble type for drinking water)

Cause of coccidiosis outbreaks: Why is there still so much difficulty from coccidiosis? Why are there so many outbreaks? Some of the reasons are:

Broilers
(1) Coccidiostat too weak for Eimeria species involved
(2) Incorrect percentages of the coccidiostat in the feed
(3) Eimeria species has become resistant to the drug
(4) Litter too damp, causing increased sporulation of the oocysts

Breeder replacements (or for laying purposes)
(1) Coccidiostat too weak for control of specific Eimeria
(2) Eimeria have become resistant to the drug
(3) Litter too dry or too wet
(4) Coccidiostat fed at too high a level, thus making it impossible for the bird to develop immunity properly
(5) Coccidiostat removed too fast
(6) Other drugs are being fed potentiating the effects of the coccidiostat

How to handle outbreaks: Outbreaks of coccidiosis, regardless of the cause, should be handled quickly. Time is most important. As feed consumption is reduced during coccidiosis outbreaks, the medicaments should be given in the water. A chicken will drink even though it will not eat. Most applications are made through the water for 3 days, then withdrawn for 2 days, then repeated for 3 days. After this, the flock is returned to the

Most coccidiostats suppress oocyst reproduction completely when they are fed at a designated level in the feed No immunity can build up during such feeding Before the bird can acquire immunity, the coccidiostat must be reduced in order that some sporulated oocysts, consumed from the litter, may be allowed to complete their life cycle A small reduction builds a little immunity and the coccidiostat may then be further reduced, producing more immunity Gradually, all the coccidiostat is removed, and immunity is complete The trick is to reduce the coccidiostat fast enough to produce just a very little coccidiosis There must be a little, or no immunity will result

How much moisture in the litter? The litter should contain 20 to 30% moisture for optimum oocyst sporulation Most types of litter should have approximately the same consistency and feeling as shavings cut from green lumber A little too much moisture is better than too little In dry periods it may be necessary to spray the litter with water to raise its moisture content

Starting the coccidiostat withdrawal period The coccidiostat should be fed at its full level during the first 5 or 6 weeks of the chick's life, then the withdrawal should start The amount of drug added to the feed should be reduced gradually over a period of 10 to 12 weeks Never withdraw the drug suddenly Remember, the drug with the greatest anticoccidial potential will require the longest withdrawal period Only a careful study of the birds will determine whether withdrawal is proceeding correctly

Immunity is not to be produced in broilers There is not time enough prior to the age at which broilers are marketed to develop an immunity to coccidiosis and allow the birds to recover All drugs should be fed at full strength (that necessary for full suppression of coccidiosis) from one day of age to broiler marketing age

Coccidiosis Inoculation

Inoculation of birds for coccidiosis is a practical procedure A product known as "CocciVac," composed of live oocysts, is given in the water or fed to chicks Eventually, oocysts are deposited in the litter, they sporulate, the bird consumes relatively small numbers, and immunity begins The program gives assurance that inoculation can start at an early age, under controlled conditions Immunity may develop in 5 or 6 weeks

The CocciVac program Be sure to follow directions as printed on the container Briefly the procedure is as follows

(1) Vaccinate only healthy chicks
(2) A program of litter management must be followed
(3) Birds should be 10 to 12 days of age when CocciVac is given
(4) Birds must be on a floor with litter so that they may have access to their droppings
(5) Select a CocciVac containing the species of Eimeria involved on the farm

Note There are several CocciVac products, each being a different combination of oocysts from various Eimeria species Some contain only 3 or 4, others may contain as many as 8

Hatchery: A general cleanup of the hatchery and incubators will remove this source of infection.

Important: Formaldehyde fumigation is not particularly effective against *A. fumigatus.* Good liquid disinfectants should be used during the cleanup procedure.

MYCOSIS

Although mycosis has been known for years, its importance as a poultry disease was not recognized until rather recently. An increasing incidence has been found responsible for great economic losses in some poultry flocks.

Other Names

- Cage diarrhea
- Candidiasis
- Crop mycosis
- Intestinal thrush
- Moniliasis
- Mycotic diarrhea
- Thrush

Cause

Mycosis, in its various forms, is caused by a yeast-like mold, *Candida albicans.* Although not a serious disease when the number of *C. albicans* is low, a large population of the mold will overwhelm the bird's defenses. Feed efficiency is lowered, mortality will ensue, and there may be great economic loss.

Mycosis may complicate the recovery from other diseases, as coccidiosis and viral infections. On occasion the prolonged feeding of some antibiotics in the treatment of other diseases may alter the intestinal flora to such an extent as to allow the fungi to increase in number.

Diseases Confused with Mycosis

- Coccidiosis
- Nonspecific enteritis

Symptoms

The symptoms occur in the upper portion of the digestive tract, particularly the crop, proventriculus, and gizzard. Ulcers appear on the lining of these organs. They vary in size from small to large.

As the disease advances, and more of the digestive tract is involved, the birds take on a general appearance of unthriftiness; the feathers are ruffled, the birds droopy. In many respects they may resemble those in a flock infected with coccidiosis. Diarrhea is almost always present.

Transmission

Outside the chicken, the molds grow rapidly in the presence of heat and moisture and consequently are more prevalent during the summer months. They are the result of contamination in the poultry house, and are easily ingested by the chicken, usually through the drinking water. Use a water sanitizer.

normal coccidiosis-control program If there are reasons for failures in the first place, make corrections at this time

ASPERGILLOSIS

Although not a serious disease, Aspergillosis is common in many instances where poor poultry husbandry is practiced It is mainly a disease of young chicks

Other Names

Brooder pneumonia
Mycotic pneumonia
Pneumomycosis

Cause

The disease is caused by a fungus, *Aspergillus fumigatus* Normally this fungus grows on decaying organic material in the chicken house and in the hatchery, but it also has the ability to reproduce itself in certain tissues of the bird

Diseases Confused with Aspergillosis

CRD
Respiratory diseases

Symptoms

The lungs are the major area of internal infection A close examination of the lung tissue will show small nodules that are hard and yellow There may be but a few in some cases, in others there may be hundreds In some instances the fungus gains entrance to the air sacs, and a respiratory condition evolves However, there is no coughing or sneezing

Chicks have few external symptoms, except for an occasional involvement of the eye, causing semiblindness As the fungus continues to grow in the lungs and air sacs, flock mortality increases It may be quite high in young chicks Older birds are able to withstand the fungal growth, and few birds are affected

Transmission

Spores from the fungus dry and are transported easily from chick to chick by way of the air This may occur in the hatchery or in the brooding house The incubator may become a source of contamination

Diagnosis

In many instances a visual examination of the sliced lung will show the nodules, and form a basis for diagnosis In others, it will be necessary to submit chicks to the laboratory Here the suspected tissue is cultured and examined microscopically

Treatment

Poultry house If the disease can be diagnosed in its early states, a thorough cleaning of the brooding premises will eliminate the source of infection, and the disease will subside Any moldy feed should be removed, bulk feed bins cleaned, old litter removed from the house and replenished with new, and waterers and feeders cleaned and disinfected

Symptoms

FLS appears only in good-laying flocks. Most birds appear in good physical condition. For this reason there is little indication of the disease until egg production gradually drops between 10 and 40% or the flock fails to have a high peak of egg production. The problem is more acute with birds housed in cages than with those housed on the floor.

Post-mortem examination will reveal an enlarged, fat and friable liver, tan in color. Obesity, as indicated by internal fatty deposits, will be evident.

Treatment

The addition of the following to the feed has been shown to alleviate the condition in laying flocks.

Add to ton (2,000 lb) of regular feed:

10,000 IU vitamin E
1,000 gm choline
12 mg vitamin B_{12}
908 gm inositol

Supplement expensive: The above supplement is expensive, but probably will not compare with the cost of the lowered egg production when the condition arises.

When to add the supplement: If the laying birds in a cage operation appear healthy, but egg production is dropping steadily, many poultrymen feed the supplement for a period of two weeks, then check the response. The fat content of the liver should be reduced.

Control

There is no feeding program that will prevent the occurrence of FLS. However, there are indications that attention to the following possible causes of the disease may be of importance in managing the flock:

(1) low feed consumption in the presence of high egg production;
(2) stress as the result of disease outbreaks;
(3) lack of bulk in the diet;
(4) protein intake too low to sustain high egg production;
(5) protein too high in realtion to energy value;
(6) hot weather when it reduces feed consumption suddenly;
(7) sudden interruption of egg production from managerial factors, e.g., light reduction, lack of water, etc.

CAGE LAYER FATIGUE

It is known that the breaking strength of bones from layers held in cages is less than that of bones of birds kept on a littered floor. This difference is great enough at times to cause difficulties with caged layers. Furthermore the brittleness of the bones of caged birds at the end of their laying year may be so great as to make the spent hens unacceptable for poultry processing; their bones disintegrate, causing fine splinters in the meat removed in the process of making soup and other food products.

Diagnosis

Although some evidence of the disease may be detected during an examination of the lining of the upper portion of the digestive tract, a laboratory examination is necessary for diagnosing most cases

Treatment

There are two avenues of treatment

(1) *Nystatin* A relatively new drug, nystatin has been found to have the necessary properties for alleviation of the distress caused by mycosis Nystatin is sold under the trade name, "Myco 20," and it contains 20 gm of nystatin per pound (454 gm) of mixture

The value of nystatin will be enhanced if the source of the mold is removed A general program of cleaning should be made a part of disease control

Nystatin dosage Mix 5 lb (2 25 kg) of Myco 20 in each ton (2,000 lb) of feed Feed the mixture for seven to ten days If the symptoms are not alleviated, the dosage should be doubled and fed for another seven days

(2) *Copper sulphate* Copper sulphate is used as the next best treatment Add one level teaspoonful of powdered bluestone (copper sulphate) to each 2 gal of drinking water The drinking water must be kept in nonmetallic containers

Control

Nystatin also may be fed continuously as a control measure The dosage for such medication is at the rate of 2 5 lb (1 35 kg) of Myco 20 per ton (2,000 lb) of feed Prior to slaughter, no withdrawal of the drug is necessary

FATTY LIVER SYNDROME

Fatty liver is sometimes the end result of any of several specific diseases There are also other factors that will cause an increased deposition of fat in the cells of the liver toxins, metabolic disorders, nutritional disturbances, and endocrine imbalances Fatty liver syndrome represents one specific type of fatty liver

Cause

The exact cause of increased fat deposits in the liver of the chicken affected with FLS is not known It has been impossible to produce the condition experimentally However, there is now adequate evidence to state that FLS is of nutritional origin, and that it is not pathogenic There appears to be a breakdown of the metabolic processes involved in the synthesis and mobilization of lipids, particularly during the stress created by heavy egg production There is some evidence FLS may be the result of an inadequate supply of the vitamin inositol

Some scientists believe that certain lipotropic agents (used for fat transport in the body), methionine, choline, and vitamin B_{12}, are involved in the production of FLS Others feel that selenium is involved Still others believe the birds consume too much protein in relation to carbohydrate

blue, and dried. The crop is sour; and there is a peculiar fecal odor. Egg production will drop

In most instances the disease occurs just before egg production begins, many times when the birds are being moved from the growing house to the laying house. It is more common during the fall, particularly during hot weather. Mortality may be between 5 and 25%.

Transmission

The method of transmission is unknown, but when a flock is affected most of the birds will show some evidence of the disease

Diagnosis

Diagnosis is difficult in minor outbreaks because the symptoms are not evident, but in severe cases the changes in the appearance of the bird are enough to define the difficulty. Laboratory diagnosis too is difficult, tests are made to identify other confusing diseases, then by a process of elimination it may be possible to make a diagnosis. A study of the blood may show monocytic white blood cells Up to 20% of the white cells may be affected.

Treatment

The broad-spectrum antibiotics seem to be successful in the treatment of avian monocytosis Chlortetracycline, oxytetracycline, or penicillin may be used. They should be given in the drinking water as the feed intake is very low in acute outbreaks Provide 100 ppm in the drinking water.

Control

Several means of eliminating outbreaks have been suggested, but their benefit is not always observable

(1) Complete vaccinations one month before start of egg production.
(2) Feed an antibiotic 3 days previous to, and 3 days after, a stress (moving, vaccinating, off feed)
(3) Move birds carefully and during the cool hours of the day

AVIAN INFECTIOUS HEPATITIS

At times this disease is important. Its incidence seems to be confined to certain parts of the world. Although minor in comparison with many other poultry diseases, its importance cannot be neglected

Other Names

Avian hepatitis
Infectious hepatitis
Vibrionic hepatitis

Cause

The disease is caused by one of the bacteria in the genus Vibrio. It is as yet unnamed

Symptoms

The affected flock shows many pale birds with withered, scaly combs There is a watery, greenish diarrhea. Egg production suffers

Other Name

Cage paralysis

Cause

There is some indication that the difficulty may be due to an inadequate amount of inorganic phosphorus in the ration However, this thought is not shared by all scientists Feeding experimental diets with little or no inorganic phosphorus will not produce the symptoms, nor will adding inorganic phosphorus to the ration increase the strength of the bones There is no indication that high egg production is a contributor to bone fragility Stress may be involved

Symptoms

After long periods of egg production caged layers have difficulty in standing, and their body is held in a vertical position They may lose control of their legs, and lie on their sides, indicative of a type of paralysis Usually there is no loss of egg production, shell quality or interior egg quality Some of the bones may be fractured, some will break when the bird is handled The ribs may be beaded at their cartilagenous junctures There may be fractures of the fourth and fifth thoracic vertebrae There is little mortality, the birds appear healthy and pert

Treatment and Control

There is no known method of treatment There is some evidence that the larger the number of layers in a cage, the lower the incidence of cage layer fatigue One experiment showed that feeding a ration containing 6% calcium just before the birds were slaughtered increased bone strength

AVIAN MONOCYTOSIS

Although not as common as a few years ago, avian monocytosis is prevalent in some poultry areas

Other Names

Blue comb disease
New wheat disease
Nonspecific infectious enteritis
Pullet disease

Cause

Although the exact cause of this disease is unknown, it is probably the result of an infectious virus that inhabits the intestinal tract

Diseases Confused with Monocytosis

Cholera
Nephritis (and nephrosis)
Typhoid

Symptoms

There is a sudden loss of appetite, and the chickens appear dull Thirst is increased There is a dehydration of the birds, the combs and wattles become dark,

Causes in Field Cases

Although there seems to be no pattern to the cause of hysteria, most cases may be traced to a mismanagement or stress factor. Each case will be the result of a different factor. Some of the causes are thought to be:

(1) crowding;
(2) poor ventilation;
(3) picking (poor or no debeaking);
(4) insufficient protein consumption;
(5) hot weather;
(6) decreased feed consumption;
(7) high levels of dust in the poultry house;
(8) excessive ammonia in the poultry house;
(9) lights flashing in the poultry house;
(10) sudden noise;
(11) insufficient space in floor houses;
(12) a large number of birds in an individual cage.

Hysteria affects birds of all ages, but the damage to the flock is greater in the case of laying birds. Many times the hysteria will begin when the birds are young, then take on greater proportions when they begin to lay.

Drop in feed consumption first indication: Evidently hysterical birds lose their appetites and do not consume a normal amount of feed. A drop in flock feed consumption, along with the flightiness should present a positive diagnosis.

Control

Permanent control can be accomplished only when the cause of the difficulty is removed. Every effort must be made to determine the management and other factors that are responsible. Any treatment to alleviate the condition must be considered as only temporary. Once the treatment is withdrawn the hysteria may return if the cause is still there.

Removal of toenails: Apparently pain is a factor in producing hysteria; and hysterical birds scratch and claw other birds. At the Washington Experiment Station it was shown that removing the toenails of day-old chicks prevented hysteria for as long as eight weeks, after which the nails had grown back and some hysteria was initiated.

Fewer birds in large cages: In a supplementary trial at the same experiment station hysteria developed when 40 pullets were kept in a cage, but seldom when 20 birds were in a unit. There was no hysteria when the pullets were in six-hen and individual cages.

Color of artificial light: Further research work showed that red light did not reduce the incidence of hysteria, although it did reduce cannibalism. The onset of hysteria was delayed when blue lights were used, but once hysteria began the incidence was greater than with white light.

Chicken sounds: Some contend that the sounds from a radio playing continuously in the chicken house will subdue the birds and help prevent hysteria. Others have recorded the voices of "happy" hens in the course of eating or laying and have played these recordings back in other chicken houses to help reduce hysteria. In some instances these broadcasts have

The liver may appear swollen with pinpoint hemorrhages The wall of the gall bladder is thicker than normal Necrotic lesions also may be observed on the heart and kidneys The birds are anemic

Transmission

The organism is spread through the droppings, and consequently is easily transmitted from bird to bird in the pen, and from house to house through footwear, clothing, equipment, and feed

Diagnosis

Four or five good representative sick birds should be submitted to the laboratory Although lesions are quite indicative of the disease, an accurate diagnosis is made by demonstrating the vibrio organism in the bile In some instances the organism may be recovered from seemingly healthy individuals, thus their presence does not always indicate that the flock is affected with vibrionic hepatitis

Treatment

Feeding furazolidone at a level of 200 gm per ton (2,000 lb) of feed for 7 days has produced good results One intramuscular injection of dihydrostreptomycin also is good Inject 250 mg per adult bird, smaller dosages for smaller birds Supplement the diet with vitamin A

Control

Apparently the disease is more prevalent in flocks that are in a weakened condition because of some stress, particularly those stresses caused by other diseases Coccidiosis seems to be an important contributor to the stress condition Crowding is another Some feel that any condition that upsets the normal intestinal flora may cause the vibrio to become pathogenic

Flock management becomes important in any preventive program The disease is not prevalent when birds are raised on wire floors Do not track the organism from flock to flock

AVIAN HYSTERIA

There is no doubt that avian hysteria may express itself to the extent that it becomes a major disaster Hysterical flocks are not common, but once the birds are inclined there seems to be little that can be done to control the difficulty Hysteria must not be confused with general nervousness found in some of the Leghorn strains Also, there is no indication that nervous flocks will show a greater incidence of hysteria

Symptoms

The first indication of hysteria is evident when a few of the birds seem to become almost "wild" Anything unusual seems to excite them and they fly over the tops of other birds until a piece of equipment or fence stops them Gradually more birds become affected Many birds are injured during their wildness Finally, the whole flock will be affected Birds pile up at the end of their flight, and many birds suffocate More and more things seem to excite them, and the difficulty reaches major proportions

Parasites, Insects, Mites, and Rodents

Each year parasites and predators cost the poultry industry millions of dollars No one knows the actual figure. Some costs are direct, some indirect.

There are many poultry parasites, but relatively few are of major importance to the poultryman. Some live inside the bird, others on the bird's surface. Certain mites are parasites of chickens, and when their population is large, they affect growth and egg production Some insects are a continual problem, and although they do not greatly affect chickens, they inhabit poultry farms where they breed and grow, constituting a general nuisance to people and animals in the vicinity. Rodents seldom attack any but young chickens, but they do devour huge quantities of poultry feed, create a general uncleanliness about the premises, and spread many poultry diseases.

INTERNAL PARASITES

Large Roundworm

The large roundworm, *Ascaridia galli*, is an intestinal parasite of the chicken Of the several similar parasites invading the intestines, the large roundworm probably inflicts the most damage.

Female worms produce a form of egg which is expelled from the chicken in the fecal material The shell of the egg consists of three layers of tough material and protects the developing larva during its growth Many acids and other chemicals will not affect the shell. The larva matures in 10 to 14 days, and the egg loses its outer shell. The remaining egg is ingested by the chicken and within a few hours it hatches in the crop, proventriculus, gizzard, or small intestine At this time the larva imbeds itself in the tract lining. After another 21 days the larva develops into an adult in the small intestines, where it floats in their contents Seven days later it is capable of producing eggs. Mature worms may reach a length of three inches, they are grey in color, and easily visible to the naked eye.

A small infestation of roundworms does little damage to the host bird, but when the worms become numerous the birds become unthrifty, and growth and feed conversion are impaired Young birds show more damage than older birds Mortality is seldom increased by the worms themselves, but when other conditions are present, such as some diseases, death losses will become important

Transmission The embryonated egg is the infective stage of the life cycle Each worm is capable of producing thousands of eggs, many of which soon reach other birds. The eggs are especially hardy; some will live outside the host for several years Eggs may get to other poultry houses by way of shoes, equipment, truck tires, etc.

Treatment Treatment involves upsetting the life cycle of the worms, either by causing the mature worms to be expelled from the intestinal tract, or preventing the production of eggs The following programs are used:

(1) *Piperazine*: Piperazine represents a purge type wormer for adult birds only. It removes the worms from the intestinal tract It should be

been of little help, in others, they have reduced hysteria in affected flocks, but the cessation was not permanent unless the cause was eliminated

Treatment

Treatment may have some effect, but by no means is any treatment consistent in reducing hysteria Usually, a treatment may help return the birds to a normal condition only as long as it is continued Once it is discontinued, the birds again become and remain hysterical until the original cause is eliminated Some of the following recommendations may prove of value

Debeaking If birds have not been debeaked, or were improperly debeaked, a good debeaking may prove valuable If hysteria has been a major problem on a poultry farm, extreme care should be used in removing the beak at debeaking time This is particularly true when young chicks are debeaked at 6 to 9 days of age

Tranquilizers There are tranquilizers on the market that are practical for chickens A small dose may aid in quieting the flock But again, the original cause of the hysteria must be removed

Niacin There is some indication that additional amounts of niacin in the diet are of value in quieting the birds

Dosage Add 0 4 lb (182 gm) of niacin to each ton (2,000 lb) of the ration Feed for nine days If hysteria is not reduced, repeat the feeding for another nine days

suffer in layers. Utilization of vitamin A is impaired, producing the poor feed efficiency mentioned above. Capillary worms are very small. Their presence may be observed if the mucus is scraped from the intestinal wall, water added, and the mixture passed through a special screen having a very fine mesh.

Treatment: Treatment is by the following:

(1) *Hygromycin B* (Hygromix): This antibiotic is quite specific for capillaria worms. The amount to add to the feed is the same as for treatment of large roundworms.

(2) *Coumaphos* (Meldane®): Although some drugs are used for the treatment of the capillaria worm, only one, coumaphos, is legal in the United States. Special precautions in its use are necessary.

Tapeworm

Although there are several tapeworms involved with chickens, only one is of importance, *Railleitina cesticullus.* It is a segmented flat worm, from very short to several inches in length. The head imbeds in the intestinal wall, and new segments continually grow behind it, each segment being a separate entity capable of its own digestion and reproduction. Segments at the end of the worm contain eggs; these segments continue to break off and pass from the bird through the feces.

Transmission: Transmission is by an intermediate host. Eggs expelled from the birds are consumed by several types of insects. Transmission is consummated when a chicken eats any insect containing the ova of the worm. With the advent of better methods of producing poultry, the tapeworm now has little importance. Even when their incidence in the intestinal tract is great they do not seem to harm the bird.

Dibutyltin dilaurate: This drug is sold in combination with piperazine and is effective in the removal of tapeworms. Only when the head of the worm is removed will control be effective; otherwise new segments will appear. Dibutyltin dilaurate is effective in this respect, but caution should be taken in its use. Treat only highly infected flocks. Do not feed to laying flocks.

be fed intensively for a short period Usually it will not affect the bird, but if laying birds are in a stress period piperazine may produce some drop in egg production

The drug does not prevent reinfestation because it does not kill the eggs, and as the purged birds soon pick up eggs from the litter, the life cycle starts again Removing the litter after drug use will remove the source of the supply of old eggs

(2) *Hygromycin B* (Hygromix®) An antibiotic, hygromycin has been found to possess the property of disrupting the life cycle of roundworms by preventing them from producing eggs It does not create a stress It is given in the feed, and fed over a period of six weeks as follows

Pullets Feed 12 gr of hygromycin B per ton (2,000 lb) of feed starting at 12 to 14 weeks of age

Layers Feed 12 gr of hygromycin B per ton (2,000 lb) of feed continually

Note When Leghorns are consuming feed at the rate of 20 lb (9 1 kg) or over per 100 birds per day, and heavy breeds at 30 lb (13 6 kg) or over, reduce the feed level of the antibiotic to 8 gr per ton

Control Clean litter is an effective method of reducing the number of worm eggs in the floor covering, but not an absolute method of control Birds on wire floors are not affected with worms

Small Roundworm

Small roundworms *Heterakis gallinarum* are sometimes known as *cecal worms* The life cycle is similar to that of the large roundworm except that the worms end up in the ceca instead of the small intestine They attain a length of ½ to ¾ in (1 3–1 9 cm) In the chicken this worm is of little economic importance, but as it is associated with blackhead it takes on importance in the turkey

Transmission Same as for the large roundworm

Treatment Little attention is paid to the incidence of the small roundworm in chickens The cecal location of the worms makes it difficult for any drug to reach the seat of infestation, as most of the intestinal contents bypass the ceca in the course of digestion

Hygromycin B This antibiotic has some value in the treatment for cecal worms Feeding recommendations are the same as for treating birds with large roundworms

Capillaria Worm

The capillaria worm, *Capillaria obsignata*, is a very small parasite inhabiting the small intestine Its life cycle is similar to that of the large roundworm except that the capillaria worm locates in the upper two thirds of the small intestine, usually the duodenal loop It imbeds itself in the mucosa, where it spends its entire life when in the bird The wall of the gut shows hemorrhages, and becomes thickened The greater the number of worms, the more pronounced the difficulty Growth and feed conversion are affected in growing birds, and egg production may

INSECTS

Lice

Only biting lice attack chickens and the biting aggravates the bird. The more lice present, the more aggravation. When there are thousands, egg production, growth, and feed conversion may suffer.

Lice spend their entire lives on the birds. They do not migrate, for off the chicken, they will die in five or six hours. Eggs usually are laid on the feathers where they are held by a type of glue. The eggs hatch in a few days to two weeks. Lice are chewing insects and live on scales of the skin and feathers.

Types of lice:

body louse (three types and most important group);
head louse;
shaft louse;
wing louse;
fluff louse;
brown chicken louse;
large chicken louse.

Darkling Beetle *(Alpitobius diaperinus)*

This insect lives in the soil and is abundant where dirt floors are used in poultry houses. The adults are about ¼ inch long and dark brown in color. Some scientists have associated the lesser mealworm with leukosis, having found that the leukosis virus remains viable in both the larva and adult worm. When chickens eat either the larva or adult worm they may develop a form of leukosis.

Flies

There are thousands of species of flies; only a few are of importance to the poultryman. Flies have a life-span of from 2 to 5 weeks. A female will lay 4 or 5 groups of eggs of 50 to 250 each during her life. In 1 or 2 days the larvae develop, and remain in this stage for from 4 to 30 days, during which time they stay in a moist place. They then migrate to a drier area where they form pupae. After 4 to 12 days in this stage the adults emerge, and the life cycle is complete.

Species of flies common to poultry farms are:

Housefly	False stable fly
Little housefly	Black garbage fly
Stable fly	Drone fly

Pesticides

A group of chemicals has been developed to aid in the control of external parasites, but most of these should be used cautiously Some have not been approved for use in the United States, and their safety may be questioned elsewhere Some may only be used according to specific methods of application

Government agencies have set levels on most drugs that are allowed in poultry meat or eggs These are known as *tolerance levels* When either poultry meat or eggs contain more of the drug than the tolerance level, the product will be condemned as unfit for human consumption If the flock that laid condemned eggs can be located, it too will be condemned, and must be destroyed The birds cannot be processed and used for food, as they too will contain residues Presently U S approved pesticides are listed below, but some states restrict the use of some of these

Carbaryl (Sevin®)	Cannot be used as a dust on laying hens or *within seven days of slaughter*
Coumaphos (Co-Ral®)	For lice and mites Use but once a week and not during stress Spray on birds Under some conditions it may be used on surfaces and in litter Spray 1 gal per 100 birds Dust 1 lb per 100 birds
Naled (Dibrom®)	Spray on chickens, or apply on litter *when birds are over six weeks of age*
Dimethoate (Cygon®)	For interior surfaces and fly maggots, but *not when birds are present*
Malathion	One of the safest in either spray or dust form Spray birds or litter, or dust birds or litter
Ronnel (Korlan®)	Can be used under cages only
Rabon®	At lower concentrations may be sprayed on birds for control of lice and mites

Tolerance levels for pesticides In the United States the tolerance levels of drugs in poultry meat and eggs are constantly changing as new information is obtained In some cases there are not enough data to enable the government to establish a tolerance At present these levels and feed withdrawal periods are

Chemical	Tolerance Level in Meat ppm	in Eggs ppm	Feed Withdrawal Period days
Carbaryl	5 0	0 0	7
Coumaphos	1	0 1	0
Malathion	4 0	0 1	0

External poultry parasites that are of economic importance include but a small percentage of those found on poultry There are two main groups (1) lice and (2) mites

Lice are insects, they have six legs Mites are not, adults have eight legs In many instances however their habits are the same Sometimes the control methods are similar

(2) Spray	Coumaphos (Co-Ral): Thoroughly clean the building, then spray the interior.
(3) Spray	Malathion: Thoroughly clean the building, then spray the interior.
(4) Spray	Rabon
Northern fowl mite	
(1) Dust	Carbaryl (Sevin): *Treat only the litter*
(2) Spray or mist	Carbaryl (Sevin): Spray caged birds with electric misting machine.
	Coumaphos (Co-Ral): Spray caged birds
	Rabon

PREDATORS

Predators on poultry farms are confined to rats and mice. The economic loss to the poultry industry because of these runs into the millions of dollars. They eat and destroy feed, transmit diseases, and create a general nuisance. Rats will produce three to 6 litters of 7 to 8 young each during a year. A few migrating rats will soon produce a large population.

Rat and Mice Bait

Other than a cleanup campaign, baits are the most effective means of eradicating rats and mice. The latest killer is a chemical known as warfarin. Combined with sulfaquinoxaline it is sold under the name Prolin. When Prolin is consumed for several days, the rats and mice die suddenly as a result of internal hemorrhage. Warfarin reduces the clotting powers of the blood, causing the animals to hemorrhage. Sulfaquinoxaline inhibits the growth of those intestinal bacteria producing vitamin K. When the sulfaquinoxaline is not added, the vitamin K tends to increase blood clotting, working against the warfarin. Sulfaquinoxaline reduces the amount of vitamin K available in the rat or mouse.

Other anticoagulates: There are other chemicals that reduce the clotting properties of the blood. Consult your chemical supply house for those available in your area.

Prolin is added to a bait such as corn, corn oil, sugar, etc. However, rats and mice are very suspicious at times and may refuse the bait material unless an appetizer, specific for rats and mice, is added.

Generous Baiting Required.—The number of bait stations is governed by the area involved and the density of the rat or mouse population. But stations should be abundant. As rats or mice seldom cross wide barren areas or expanses, but rather move about the margins of these places, bait stations should be near walls, next to burrows and paths.

How to bait: Place the bait in a pan under a long board attached to the wall. A long box may be used with openings at each end for the rats and mice to come and go. Place fresh water near the bait stations to increase the bait consumption.

Bait should be fresh: Rats and mice will not consume the bait once it becomes old, dusty or stale. Bait stations must be replenished every day or two. Do not put out more bait than the animals will consume in 1 or 2 days.

the bird as much as the red mite Some Northern fowl mites may be found at all times on affected chickens They consume large amounts of blood and congregate near the moist area of the vent Here the skin becomes reddened and scaly

FLEAS AND TICKS

Fleas

In some areas of the world the *sticktight flea* may find its way to chickens Hundreds of fleas may imbed their heads in the skin in the region of the head of the chicken There may be enough to seriously affect the growth of young chick ens and the egg production of older birds

Ticks

At times the *fowl tick* inflicts heavy damage on chickens This tick lives in lit ter and in nests, then goes on the bird at night to feed If sand is used as the lit ter in a chicken house, ticks find their way to it and remain there during the time they are not on the bird

PREVENTION OF EXTERNAL PARASITES

Many of the chemicals used for the control of external parasites of poultry con trol more than one parasite Some chemicals are used for the destruction of the adults, some the eggs, and some the larvae Recommendations are as follows

Lice	
(1) Spray	Coumaphos (Co Ral) Malathion Rabon®
(2) Mist	Carbaryl (Sevin) Use an electric mist machine
(3) Dust	Carbaryl (Sevin) Coumaphos (Co Ral) Malathion Rabon®
Fleas	
(1) Spray	Carbaryl (Sevin)
(2) Dust	Carbaryl (Sevin)
Lesser mealworm	
(1) Spray	Carbaryl (Sevin)
(2) Dust	Carbaryl (Sevin)
Chicken red mite with birds in the house	
(1) Spray or dust	Carbaryl (Sevin) *Do not apply directly to eggs nest litter, feed or drinking water*
(2) Spray on birds	Rabon
(3) Spray or dust	Coumaphos (Co Ral) *Do not apply directly to eggs nest litter, feed or drinking water*
(4) Spray or dust	Malathion *Do not apply directly to eggs nest litter, feed, or drinking water*
Chicken red mite with no birds in the house	
(1) Spray	Carbaryl (Sevin) Thoroughly clean the building then spray the interior

Disease Prevention Management

Undoubtedly prevention is better than cure Today's poultry programs incorporate many procedures necessary to keep flocks in a healthy condition Necessarily these are not just vaccinations, but constitute a great number of management and other practices Many are on a continuing basis cleanliness, disposal of refuse, stress prevention, and pollution control are examples All possible endeavors to keep the flock at high productive capacity are requisite to economical meat, chick, and egg production Treating a flock that has lost some of its efficiency because of disease, stress, or abuse represents a stopgap approach, prevention is a much better and more practical means of dealing with disease

A detailed analysis of continuing practices necessary to a prevention program follow Even then there may be pitfalls, adhering to all such practices will not give complete assurance that there will be no difficulties with the flock

Prevention Requires Regular Procedures

The practices that must be followed regularly on a poultry farm may be grouped as follows

(1) management,
(2) bloodtesting,
(3) sanitation,
(4) vaccination,
(5) coccidiosis control,
(6) stress prevention,
(7) parasite, lice, mite, and rodent control,
(8) dead bird and refuse disposal,
(9) pollution control

Management

The poultryman must be cognizant of the many factors that aid in keeping his flock healthy, and his products high in quality Many of these factors are on a day to-day basis, others require attention less frequently

(1) *Isolation* Modern disease control programs call for isolation of the poultry house, flock, or hatchery The *all in, all-out* system is favored, it constitutes starting a group of chickens in one house and leaving them there until the end of their productive or growth period Many times the all in, all out system includes the entire poultry farm

(2) *Housing and equipment* Good housing and good equipment are necessary in today's poultry production. Poor housing and equipment may cause unnecessary stress on the birds with resulting greater morbidity, mortality and inefficiency Profit will be lowered

(3) *Hatching* The details of hatchery operation are many, the improvement in hatchability through each detail is small, yet a little improvement here and there adds up to profit increases that are meaningful

(4) *Quality chick* Many things go into the production of a chick of quality These have been detailed throughout this text Most of them call for a regular vigil, there can be no laxity on anyone's part The objective of a breeder and hatchery operation is to produce a good chick, the foundation on which the commercial poultryman builds his business

Prolin Must be Consumed for Several Days —The process of creating the hem orrhagic condition takes time Rats and mice must eat the bait for several days before they die Be sure they are eating the bait Many times there will be other sources of feed in the poultry house in the feeders, in feed sacks, or in the litter Place feed sacks on horses with tin covering their legs Allow the poultry feeders to become empty at night

Cleanup Campaign Necessary

Many rats will live in debris around the poultry farm Destroying their homes through a thorough cleanup campaign is a necessary part of any eradication pro gram But do not clean up until the rats have been destroyed by the bait To clean up before baiting will only disrupt their movements and baiting will be difficult

USE OF DRUGS

Drugs should be used carefully Most of them are poisons, and precautions nec essary to the handling of such chemicals must be taken The following rules should be followed

(1) Properly identify the problem
(2) Select the correct drug or insecticide When in doubt, consult some one who knows which is the right one, and which one may be used legally
(3) Read the label carefully Many drugs and insecticides are sold under a trade name, but the label will show the list of ingredients, including the correct name of the active ingredient
(4) Follow directions Do not dilute the product and do not overadminister
(5) Store only in original containers
(6) Keep containers out of reach of children, pets, and livestock
(7) Know the antidote before opening the container
(8) After any container is empty, rinse it at least twice
(9) When burning any empty containers, stay out of the smoke
(10) Clean up after the use of any drug or insecticide

Disease Prevention Management

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(6) Keep containers out of reach of children, pets, and livestock.
(7) Know the antidote before opening the container.
(8) After any container is empty, rinse it at least twice.
(9) When burning any empty containers, stay out of the smoke.
(10) Clean up after the use of any drug or insecticide.

Item	Maximum level
Total dissolved solids	1000 ppm
Total alkalinity	400 ppm
pH	8.0
Nitrates	45 ppm
Sulphates	250 ppm
Sodium chloride (growing birds)	500 ppm
Sodium chloride (laying birds)	1000 ppm

Chlorinating Water

When water is microbiologically impure it should be chlorinated. There are several suitable chlorinators on the market, most of which operate by superchlorinating the water at the farm source. This guarantees a satisfactory level of chlorine in the water in the poultry waterers. Chlorine itself is inexpensive, but some chlorinators are costly and add to the expense of purifying the water. At a cost of US$1.00 for chlorine, about 10,000 gal of water may be chlorinated.

The addition of chlorine to water also reduces oxidation of any iron, thus eliminating some of the rust developing in pipes and valves.

Water sanitizers and vaccination: Many vaccines are administered in the drinking water. The presence of any sanitizer in the water will affect the viability of a vaccine, often making it worthless.

Warning: Do not add vaccine to any drinking water containing a sanitizer. First flush the water system several times until it is free of any sanitizer; then provide clean water to which the vaccine has been added.

Skimmilk to neutralize sanitizers: Where there is no supply of unsanitized water, the sanitizer may be neutralized by adding *dried skimmilk* to the drinking water, as follows:

Add 3.2 oz (90.7 gm) of dried skimmilk to each 10 gal (37.9 liters) of water. This is approximately 1 part dried skimmilk to 400 parts of water. Add the vaccine to the milk-water solution and mix thoroughly.

Blood Testing

Blood testing the breeding flock becomes a regular chore for those poultry operators following certain disease-control programs. Pullorum, typhoid, and mycoplasma are diseases in this group. Control programs are detailed in Chapter 41. Testing the birds must be completed on schedule; many times the testing is done by representatives of government agencies rather than by the flockowner. Prearranging a schedule will be necessary.

Sanitation Program

All poultry farms and hatcheries must be kept clean. Not only does this mean that debris should be removed on a continuing basis, but certain disinfectants must be used regularly to lower the incidence of pathogenic microorganisms.

Hatcheries must be cleaned and disinfected, either by chemicals or fumigation, or both. Drinking fountains must be cleaned daily. Nests should be cleaned and new nest litter added on a weekly basis. Chick trucks must be fumigated prior to

(5) *Hatchery chores* Debeaking, dubbing, sexing, inoculation, etc , are special services that are to be completed in the hatchery Each operation should be done with infinite care Each is a part of the program of producing a quality chick

(6) *Proper nutrition* Feeding the breeding flock correctly is a daily necessity Without adequate nutrition the birds do not produce gains in weight, feed conversion, egg production, or hatchability adequately or economically Faulty diets will lead to increased stress, which in turn increases the incidence of many disorders

(7) *Water supply* A supply of good water is essential There is no such thing as pure water All water contains many substances in solution or suspension, many of which affect its palatability and value

Water analysis Before being used, a sample of water may and should be submitted to a laboratory for analysis of chemicals and purity Some of the determinations made to evaluate its condition are as follows

(a) *Color* Any color is due to certain substances in solution such as tannin, iron salts, etc

(b) *Turbidity* Particles in suspension rather than in solution cause the water to be turbid

(c) *Hardness* Salts of calcium and magnesium form scale and sludge and cause the water to be "hard " Hardness affects the taste of water

(d) *Iron* Although iron in water seldom affects chickens it stains almost everything with which it comes in contact

(e) *pH* The pH of a solution is a measure of its acidity or alkalinity When above 7 it is alkaline, below 7, it is acid Water is normally about 7 to 7 2

(f) *Total solids* Total solids represents the total amount of solid material in a suspension or solution

(g) *Nitrogen* Two determinations may be made for the presence of nitrogen, but each is indicative of decaying organic material, and is a measure of contamination

(h) *Poisonous metals* When in excess of 0 5 ppm certain metals in the drinking water may accumulate in the bird to produce pronounced difficulties and cause illness

(i) *Bacteria* Type of bacteria, rather than number, is important to a water analysis Some bacteria may be detrimental to human beings and chickens

(j) *Sanitizers* Chlorine and other sanitizers often are added to drinking water Some, when in high proportions, may be injurious to poultry, others will tend to decrease water consumption

Maximum levels in water The following are recognized as the maximum levels of certain ingredients in a "safe" water supply for poultry

Item	Maximum level
Total dissolved solids	1000 ppm
Total alkalinity	400 ppm
pH	8.0
Nitrates	45 ppm
Sulphates	250 ppm
Sodium chloride (growing birds)	500 ppm
Sodium chloride (laying birds)	1000 ppm

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each chick delivery. Hatching eggs must be fumigated immediately after they are laid Employees must shower and change to clean clothing before entering the poultry premises. These are but a few of the programs which must be regularly followed to keep the operation clean and sanitary. There are many more.

Vaccination Program

Not only are there many vaccines, but there are numerous vaccination programs. These programs involve:

(1) type of vaccine to use,
(2) vaccines to be mixed together,
(3) vaccinations to be administered simultaneously;
(4) age of the bird when vaccinations should be given;
(5) type of bird (breeders, layers, broilers) involved.

Important There are many types of vaccines and vaccination programs Those given in Tables 43 1, 43.2, and 43 3 are only examples. They must not be construed as being practical for all areas of the world nor under all conditions. Diseases in the area, availability of vaccines, periods of stress, climatic conditions, and many other factors are involved to make up a program for a specific area Consult your vaccine supplier or specialist before initiating any vaccination program.

Broiler vaccination program The fact that broilers are marketed at eight to ten weeks of age and are not subject to poultry diseases that affect older birds makes it necessary that the vaccination program for broilers differ from that used for birds to be used for laying or breeding

TABLE 43 1

EXAMPLE OF BROILER VACCINATION PROGRAM

Age of Vaccination (Wk)	Vaccine Disease	Strain	Method of Vaccination
2-3	Bronchitis	Massachusetts and Connecticut	Ocular or water
2-3	Newcastle	B_1 type or B_1 strain	Ocular or water

Layer vaccination program Growing birds to be used later for the production of commercial eggs require a special vaccination program. Although the diseases of commercial laying strains are identical with those of breeder replacement strains, vaccinations given during the period when eggs are being produced are different or are not needed

Breeder replacement vaccination program This program is similar to the vaccination program for commercial laying strains except that breeders are vaccinated for *certain diseases* during the laying period to maintain a constant level of parental immunity in the chicks hatched from the eggs produced by the breeders. Usually these vaccinations are made every 12 weeks during the period the breeder flock is producing hatching eggs.

TABLE 43 2

EXAMPLE OF LAYER VACCINATION PROGRAM

Age of Vaccination (Wk)	Vaccine: Disease	Vaccine: Strain	Method of Vaccination
2-3	Bronchitis	Massachusetts and Connecticut	Ocular or water
2-3	Newcastle	B_1 type	Ocular or water
7	Bronchitis	Massachusetts and Connecticut	Ocular or water
7	Newcastle	B_1 type	Ocular or water
10	Laryngotracheitis	Modified	Ocular
10	Fowl pox	Modified pigeon	Wing web
6-16	Avian encephalomyelitis		Wing web or water

Water Proportioners

Many vaccines or medicaments are added to the drinking water At other times disinfectants are added to sanitize the water When automatic waterers are used it is often difficult to add anything to the water To facilitate the procedure a water proportioner may be used Usually this is a pump that operates when water from the water supply is forced through a cylinder When the proportioner is installed in the incoming water line the flow of water to the fountains in the poultry house operates the pump The pump has the ability to draw liquid from a container and

TABLE 43 3

EXAMPLE OF BREEDER REPLACEMENT VACCINATION PROGRAM

Age to Vaccinate (Wk)	Vaccine: Disease	Vaccine: Strain	Method of Vaccination
2-3	Bronchitis	Massachusetts and Connecticut	Ocular or water
2-3	Newcastle	B_1 type	Ocular or water
7	Bronchitis	Massachusetts and Connecticut	Ocular or water
7	Newcastle	B_1 type	Ocular or water
10	Laryngotracheitis	Modified	Ocular
10	Fowl pox	Modified pigeon	Wing web
10	Avian encephalomyelitis		Wing web or water
20-22	Bronchitis	Massachusetts and Connecticut	Ocular or water
20-22	Newcastle	B_1 type	Ocular or water
36	Bronchitis	Massachusetts and Connecticut	Ocular or water
36	Newcastle	B_1 type	Ocular or water
48	Bronchitis	Massachusetts and Connecticut	Ocular or water
48	Newcastle	B_1 type	Ocular or water
60	Bronchitis	Massachusetts and Connecticut	Ocular or water
60	Newcastle	B_1 type	Ocular or water

inject it into the water line at a rate proportionate to the flow of water to the watering troughs Thus, the proportion of the medicated or treated liquid always is constant The proportion may be adjusted by altering controls on the proportioner There are several proportioners on the market

Coccidiosis Control

The control of coccidiosis is a never-ending program when raising young chicks Either a coccidiostat must be used in the feed or water or a coccidiosis vaccination program must be followed Complete suppression of the organism is desirable when feeding broilers, but when the chicks are to be used for laying or breeding purposes, the coccidiosis-control program must be one that establishes immunity in the birds These are explained fully in Chapter 41

Stress Prevention

Many routines of daily procedure are necessary to prevent stress in flocks of chickens These routines are often the "little things" so necessary to keeping the flock in top condition and capable of high efficiency When birds are stressed, feed consumption drops, feed conversion is reduced, diseases are more prevalent, and egg production suffers Although stress is not easily defined, any day to-day management practice that is neglected usually will lead to a stressed condition

Parasites, Lice, Mite, and Rodent Control

There must be a planned program for the control of all in this category Each has the ability to cause increasing damage to the flock, and when there is neglect the birds cease to function at full capacity

Dead Bird and Debris Disposal

Dead birds and debris from the poultry farm and hatchery should not be allowed to accumulate This refuse must be disposed of daily and in a manner that prevents transmission of disease There are two methods

(1) *Incinerate* Special burners are on the market which will consume large quantities of both wet or dry material Most operate with either gas or oil A blast type furnace soon incinerates all the material

(2) *Use plastic bags* Bags of plastic or similar material may be used where incinerators are impractical All material is to be placed in the bags, sealed, and removed from the premises

Pollution Control

Man's environment is coming under close scrutiny in practically every section of the world Anything that pollutes it will be subject to strict regulation in the years ahead Pressures already are being placed on poultrymen to reduce their present pollution And this covers a vast array of problems manure disposal, burning and incinerating, odors, noise, unsightliness, and insects all come under the subject of environment

Most pollution from a poultry farm, as classified above, must be handled on a day to-day basis There must be a concentrated effort and program to reduce or obliterate it

VACCINATION SCHEDULE

There are two things involved in a vaccinating schedule:

(1) Schedule of the vaccination, including:
- (a) diseases for which vaccination is required;
- (b) types of vaccines to be used;
- (c) age of the birds when vaccinated;
- (d) date of each vaccination.

(2) Report of the vaccination, including:
- (a) Dates the vaccinations were given
- (b) Manufacturer and serial number of the vaccine
- (c) Name of the person doing the vaccinating

Such a schedule is necessary in order that the exact dates of vaccinations may be set up before the chicks arrive on the premises. The more flocks and ages of birds on the farm the more important the schedule becomes.

The second part of the schedule is a report of the vaccination operation. This is a record showing the actual dates of vaccination, the vaccine used, and name of the vaccinator. This report is of great importance when difficulties arise following vaccination.

A suggested form for such a schedule and report is given in Table 43.4.

MEDICATION REPORT

Another important record is the Medication Report. This is to include all medicaments given to the flock, along with other pertinent data. An example of such a report is found in Table 43.5.

DISEASE DIAGNOSTIC REPORT

On many occasions sick chickens will be taken to a laboratory for a diagnosis of the presence and identification of any diseases. A history of the flock will be of great help to the laboratory technician in making the diagnosis.

Care should also be taken to select for diagnosis birds that are representative of the sick birds in the flock. Often more than one disease will be affecting the flock. One disease could be producing high morbidity; another could be causing high mortality. Usually six to eight birds will be adequate. Include some sick, fresh-dead, and healthy birds.

Table 43.6 shows an example of an outline that should be completed and taken to the laboratory with the birds. It gives the past and present history of the flock.

SUBMITTING BLOOD AND SERUM SAMPLES

Many times chicken blood or blood serum must be submitted to the laboratory for making tests. Certain techniques are necessary to draw the blood correctly, and to submit the sample without deterioration.

Although not necessary, a plastic, disposable syringe is usually used. This not only provides a method for collecting the blood, but the tube of the syringe also acts as a container for the sample. The main points for using the syringe are:

(1) Use a new syringe and needle for each bird.

TABLE 43 4

VACCINATION SCHEDULE AND REPORT

Flock No		Breed	No Males		No Females		Date Started		
Age To Be Vaccinated	Date To Be Vaccinated	Date Actually Vaccinated	Man Who Vaccinated	Vaccinated Against	Type of Virus	Method of Vaccinating	Vaccine Manufacturer	Vaccine Serial Number	Remarks

TABLE 43 5

MEDICATION REPORT

Flock No			Breed		No Males		No Females	Date Started	
Medication									
Date from	Date to	Age of Birds	Type of Medication	Medication Dosage	Drug Manufacturer	How Drug was Administered	Feed Manufacturer if Drug in Feed	Disease Diagnosed as	Response to Treatment

TABLE 43.6

FLOCK HISTORY FOR LABORATORY DIAGNOSIS

Submitted by ______________________________ Date ________________

Flockowner ______________________________ Serviceman ________________

No. birds: On farm ____________ In flock ____________ Age ____________

No. birds submitted ____________ % of flock showing symptoms ____________

Symptoms Notice (Check):

Coughing	________	Trembling	________
Sneezing	________	Diarrhea	________
Swollen heads	________	Lame	________
Eye discharge	________	Swollen hocks	________
Paralysis	________	Dark combs	________

Additional description of the disease: ______________________________

____

____

Mortality pattern (Number of Birds)

Week Beginning	Sun	Mon	Tues	Wed	Thurs	Fri	Sat

Previous medication: ______________________________

____

____

(Circle the day in above chart when medication was given)

Report of egg production: ______________________________

____

____

(2) Blood is drawn from the underside of the wing near the "elbow," or by heart puncture. *Draw approximately 10 cc of blood, filling the syringe.*

(3) Remove the needle, separate the syringe, and seal the opening (where the needle was attached) with a hot iron or cauterizing blade of an electric debeaker.

(4) Set the tubes in an upright position, allowing the blood serum to separate.

(5) Get the samples to the laboratory as soon as possible.

(6) Do not allow samples to freeze or heat

Important When blood serum will be required in the laboratory use glass tubes rather than plastic tubes for holding the blood Serum will not separate when plastic tubes are used

SUBMITTING TISSUES FOR HISTOLOGIC EXAMINATION

On occasion it becomes necessary to submit body tissues to a laboratory for examination Not only must these tissues be removed from the bird in a prescribed manner, but they must be placed in a preservative to prevent deterioration before the histologic examination is started

How to take the tissues from the bird

Brain Remove the entire brain Do not mutilate it

Heart Extract the entire heart, then slice it through the middle with a sharp scalpel or with a pair of manicuring scissors

Liver Take several sections about ¼ in (0 64 cm) thick, cutting with a sharp scalpel

Other organs except the liver Remove the entire organ from young chicks In older birds disect a section approximately ¼ in (0 64 cm) thick with a sharp scalpel

How to preserve the tissues Fixation of the tissues is accomplished by placing them in the following solution

10% Formalin (37–40% formaldehyde)
90% Distilled water

Use about ten times as much of the above solution as the size of the tissue Keep each tissue section in a separate vial Leave in the solution for 48 hours, then pour off most of the solution, leaving only enough to keep the tissue moist Seal the container, and transfer to the laboratory

Include a complete flock history when submitting samples for examination

EVERYONE SHOULD UNDERSTAND THE PROGRAM

Many people become involved with poultry production today the poultryman, the serviceman, the integrator, and others One of these will have to initiate the program what is to be done each day, what vaccines are to be administered and when, what medications will be necessary, what are the quality standards, and what is to be done when trouble begins Confusion arises because some people will not know what the program is, what to do, or who is to do it There must be a complete understanding among the parties involved

Do you have an identifiable program? Has it been written in detail and in such a manner that no questions will arise? Has the program been discussed with those who will carry it out? Has the program been reviewed periodically? Has it been brought up to date? Are there changes? Why?

To neglect a definite written program is to ask for trouble Prevention is much better than treatment But prevention comes only through a complete understanding of the things that must be done to ward off trouble, and to know what to do when there are indications that things are not "just right"

Waste Management

Wastes associated with poultry farming have an increased significance in this day when we become aware of the effects of polluting man's environment. New words and terms have come into use to explain the problem and offer means of control. Some of these are as follows:

aerobic bacteria: Bacteria which require free oxygen (in air or water) for their metabolic processes.

aerobic digestion: Decomposition of organic material by aerobic bacteria, thereby decreasing the energy level of the material while producing little if any odor.

anaerobic bacteria: Bacteria which do not require free oxygen for metabolism and in most instances do not thrive when oxygen is present.

anaerobic digestion: Reduction in the energy level of organic material by anaerobic bacteria, usually accompanied by odors.

biological oxygen demand (BOD): A measure of the amount of dissolved oxygen absorbed by the material in question, expressed in milligrams per liter, thus indicating the amount of biochemically oxidizable organic matter.

biological stabilization: The tendency of organic matter to putrefy due to activity of bacteria.

composting: The biological stabilization of organic solids, usually through aerobic bacteria.

effluent: The discharge of liquid waste material.

faculative bacteria: Bacteria which can live and reproduce under aerobic or anaerobic conditions.

lagoon: A shallow body of water containing waste materials to be subjected to bacterial action.

oxidation ditch: A long, continuous, circular ditch or trough through which liquid organic material is circulated and aerated to provide aerobic action.

Importance of Poultry Farm Pollution

All poultry farms have a problem with pollution as we define the term today. Pressures will be made on farm owners to reduce their pollutants more and more each year.

What constitutes pollution: Most poultry farm pollution comes under the following headings:

(1) poultry manure;
(2) dead birds;
(3) hatchery debris;
(4) processing plant waste;
(5) dust from feed manufacturing plants;
(6) exhaust from internal combustion engines;
(7) air (dust and chemicals);
(8) odors;
(9) noise;
(10) contamination of drinking water;
(11) insects;
(12) unsightliness;
(13) toxic chemical residues in tissues and eggs.

VALUE OF POULTRY MANURE

Although poultry manure is a waste product, it is one that has considerable value as a fertilizer and feed nutrient

For Fertilizing the Soil

In the past, tons of poultry manure have been applied to the soil either when birds were allowed to range over the land, or the material was spread It was the accepted method of "getting rid" of it

Undoubtedly, poultry manure is a valuable soil fertilizer as Table 44 1 shows, but the day may come when soil application will not be allowed, disposal by other means will be mandatory

TABLE 44 1

AVERAGE PLANT NUTRIENTS PER TON* OF CAGE LAYER POULTRY MANURE

Manure condition	Moisture %	Nitrogen Lb N	Phosphorus Lb P_2O_5	Potash Lb K_2O
Wet, sticky	75	25	23	12
Moist crumbly	50	40	46	24
Crumbly, no dust	25	60	66	36
Dry, dusty	15	70	70	46
Completely dry	0	80	90	56

*2000 lb
Source W Va Univ Ext B 496T and Penn Univ Leaflet 255

As Poultry and Animal Feed

The fact that poultry manure contains many feed components which pass the digestive tract without digestion and numerous by products from metabolism suggests that it would have nutritional value if recycled through the chicken and other birds, and even domesticated farm animals

Manure is dried The manure is dried to reduce its moisture content and to make storage possible

Chemical analysis Although analyses of dried manure vary with the age of the bird, ration, and type of chicken involved, an average would be represented by the following figures

	%
Ash	26
Crude fiber	10
Crude protein	33 5
N free extract	22 5

Many experimental stations have worked on the nutritional value of dried poultry manure Michigan State University has accomplished a great deal in this respect, and their results show that this dried product does have exceptional merit as a feed ingredient to replace a good proportion of some regular ingredients in poultry formulas

Caution: The use of dried poultry manure has not been cleared for use in poultry feeds in the United States. More must be known about the residual effects of any drugs and other chemicals in poultry flesh and eggs when the product is recycled.

MANURE DISPOSAL

The sewage load from large poultry farms creates a problem of magnitude. In many instances, small farms can be well taken care of, but when thousands of birds are on the premises, manure disposal systems must dissipate tremendous volumes. Some data are given in Table 44.2 to show the production per 1,000 birds.

TABLE 44.2

POULTRY MANURE PRODUCTION
(4-Lb Bird)

Time Period	Pounds per Bird	Per 1,000 Birds		
		Weight	Cubic	Gallons**
Daily	0.25	250 lbs	4.9 cu ft	37
Weekly	1.75	1.23 tons*	34 cu ft	257
Monthly	7.6	3.8 tons*	5.5 cu yd	1,115
Yearly	91.3	45.6 tons*	66 cu yd	13,379

*2000 lb.
**U.S. gallons.

There are several methods of disposing of poultry waste, and many innovations of each method. These are as follows.

Spreading

In many areas it is still practical to dispose of poultry manure by spreading it on cropland or grassland. But in many instances the amount of available land is not great enough. About four tons of fresh manure may be spread on an acre of land devoted to the production of corn. Thus, 100,000 hens would require about 1600 acres of available land. To add to the problem is the fact that manure may be spread on the land during certain periods of the year. Until spreading is practical, manure must be stored, and storage produces obnoxious odors.

Dehydration

Much of fecal waste is now being dehydrated to reduce the volume and to prevent bacterial action which results in odor production. There are several types of dehydrators on the market, the temperature created in these varying from 700° to 1800°F. The length of the drying time is governed in part by the temperature, but in an hour some dehydrators will reduce the moisture content of 2.5 tons of material from 70% to about 12%. The capacity of any dehydrator is governed by the number of pounds of moisture it will remove in one hour.

Composting

Collecting poultry manure in pits under cages or slat or wire floors is gaining favor as a practical and economical way to handle poultry waste The manure may be allowed to accumulate for several years through the process of composting Aerobic bacterial action is involved Many composting pits have been in operation for several years without manure removal After six years of use, the debris in the pit should be about 2 to 4 ft deep, depending on the number of hens above it The top foot is composed of fresh manure, the bottom foot is in an anerobic condition, and the central portion is undergoing composting

The essential requirement in managing the deep pit is that the fresh, wet material be adequately aerated to remove the moisture To further the composting process and to prevent odors, the pit must be so tight that seepage water cannot enter Care must be taken to prevent waterers from leaking or overflowing into the pit, for such overflow prevents proper bacterial action in the accumulated wet manure When the procedure operates correctly, there is little or no odor arising from the pits, and manure removal may be delayed for years There is practically no problem with flies

Bressler system Dr G O Bressler has designed a two-stage drying system commonly known as the "Bressler" system The stages involved are

(1) Stirring with rakes, and drying the manure in a pit with high velocity fans to reduce the moisture content to 35 or 40%

(2) Dehydrating the partially dried material so that it has a moisture content of 10 to 12%

Lagoons

Fresh poultry manure may be flushed into an open, shallow pond known as a lagoon Bacterial action reduces the waste material to a smaller volume As bacterial growth occurs only during the warm months, the use of lagoons is seasonal The solution may be spread in a liquid state on farm land When aerobic action takes place, the lagoon produces little odor, but as the sludge builds up anaerobic activity takes place and odors may be pronounced

Oxidation Ditch

The oxidation ditch as used for poultry is really a continuous flowing trough under the birds Water is poured in the trough to keep the manure fluid, and pumps keep the sludge circulating The effluent is aerated by paddles The addition of oxygen to the material by the paddles increases the activity of aerobic bacteria, greatly reducing the incidence of any odors After four to six months, the material is removed in liquid form and usually spread on the land The material is practically odorless and there is little objection when it is spread

OTHER POLLUTION PROBLEMS

Most poultry farms are plagued with other pollution problems and a management program must be worked out to care for these

Dead birds are best incinerated, but care should be taken that little smoke and no obnoxious odors arise from the burning process Hatchery debris may be handled similarly, there are numerous commercial burners on the market that will handle this type of material Processing plant waste consisting of poultry offal

and poultry feathers is usually dried as two separate products to be used for poultry or animal feed. Dust and chemicals in the air, not only from burning, but from the chicken house, create a health hazard at times. Odors, noise, insects, and unsightliness create pollution factors of one type or another. Certain chemicals and drugs when fed to chickens may leave residues in poultry meat and eggs, and these are under close scrutiny by health experts.

Not long ago the subjects discussed in this chapter had little importance in poultry production. But times have changed, and the commercial poultryman will be held responsible for more and more factors that tend to produce an undesirable environment for human beings.

Tables and Publications

The ability to convert weights and measures is of great importance at times. The following tables of equivalents will be of great help

WEIGHT OF WATER

1 cubic foot of water weighs	62.4 lb
1 U.S. gallon of water weighs	8.33 lb
1 Imperial gallon of water weighs	10.00 lb
1 Imperial gallon of water weighs	4.54 kilos

LIQUID MEASURE

1 teaspoon	5 cc
3 teaspoons	1 tablespoon
1 tablespoon	15 cc
2 tablespoons	1 ounce
8 ounces	1 cup
2 cups	1 pint (U.S.)
16 fluid ounces	1 pint (U.S.)

EQUIVALENTS

Equivalent measures are given in the following tables for.
- linear measure,
- area,
- weight,
- liquid volume;
- dry volume.

TABLE 45 1

LINEAR MEASURE EQUIVALENTS

	Inches	Feet	Yards	Rods	Miles	Centimeters	Meters	Kilometers
1 Inch	1	0 0833	0 0278	0 0051	0 000016	2.54	0 0254	—
1 Foot	12	1	0 3333	0 0606	0 00019	30 48	0 3048	0 00031
1 Yard	36	3	1	0.1818	0 00057	91 44	0 9144	0 0009
1 Rod	198	16 5	5 5	1	0 00313	502 92	5 0292	0 005
1 Mile	63 360	5 280	1 760	320	1	160 934	1 609.3	1 609
1 Centimeter	3937	0 0328	0 0109	0 00198	—	1	01	0 00001
1 Meter	39.37	3 2808	1 0936	0 1988	0 00062	100	1	0 001
1 Kilometer	39 370	3 280 8	1 093 6	198 839	0 621	100 000	1 000	1

TABLE 45 2

AREA EQUIVALENTS

	Sq In	Sq Ft	Sq Yards	Sq Rods	Acres	Sq Miles	Sq Cm	Sq Meters	Hectares
1 Sq Inch	1	0 0069	0 00077	—	—	—	6 4516	0 00065	—
1 Sq Foot	144	1	0 1111	0 00367	—	—	929 03	0 0929	—
1 Sq Yard	1 296	9	1	0 0331	—	—	8 361 3	0 8361	—
1 Sq Rod	39 204	272 25	30 25	1	0 00625	—	—	25 2929	0 00253
1 Acre	—	43 560	4 840	160	1	0 00156	—	4 046 9	0 4047
1 Sq Mile	—	—	3 097 600	102 400	640	1	—	2 589 988	259
1 Sq Centimeter	0 155	0 00108	00012	—	—	—	1	0 0001	—
1 Sq Meter	1 550	10 764	1 196	0 0395	0 00025	—	10 000	1	0 0001
1 Hectare	—	107 639	11 959 9	395 37	2 471	0 00386	—	10 000	1

TABLE 45 3

WEIGHT EQUIVALENTS

	Ounces	Pounds	Short Tons	Metric Tons	Long Tons	Grams	Kilos
1 Ounce	1	0 0625	—	—	—	28 349	0 0284
1 Pound	16	1	0 0005	0 00045	0 00045	453 592	0 4536
1 Short ton	32 000	2 000 0	1	0 9072	0 8929	907 184	907 2
1 Metric ton	35 274	2 204 6	1 1023	1	0 9842	1 000 000	1 000
1 Long ton	35 840	2 240 0	1 12	1 016	1	1 016 046	1 016
1 Gram	0 035	0 0022	—	—	—	1	0 001
1 Kilo	35 274	2 2046	0 0011	0 001	0 00098	1 000	1

TABLE 45 4

LIQUID VOLUME EQUIVALENTS

	Fluid Ounces (U S)	Pints (U S)	Quarts (U.S)	Quarts (Imp)	Gallons (U.S)	Gallons (Imp)	Cu In	Cu Ft	Liters	cc
1 Fluid Ounce (U S)	1	0 0625	0 0313	0 0261	0 0078	0 0065	1 805	0 001	0 0296	29 6
1 Pint (U.S)	16	1	0 5	0.4163	0 125	0 104	28 875	0 0167	0 4732	473 2
1 Quart (U S)	32	2	1	0 8326	0 25	0 208	57 75	0 0334	0 9463	946 3
1 Quart (Imp)	38 43	2.4	1 201	1	0 3002	0 25	69.354	0 0413	1 1365	1 136 5
1 Gallon (U S)	128	8	4	3 33	1	0 833	231	0 1337	3 785	3 785
1 Gallon (Imp)	153 7	9 608	4 804	4	1 201	1	277 42	0 1605	4 546	4 546
1 Cu Inch	0 554	0 0346	0 0173	0 0144	0 0043	0 0036	1	0 00058	0 0164	16 387
1 Cu Foot	957 51	59 844	29 922	24 883	7 481	6 221	1 728	1	28 316	28 316
1 Liter	33 815	2.1134	1 0567	880	2642	220	61 026	0353	1	1 000
1 Cu Centimeter	0 0338	—	—	—	—	—	0.061	—	0 001	1

TABLE 45 5

DRY VOLUME EQUIVALENTS

	Dry Pints	Dry Quarts	Pecks	U.S Bushels	Cu In	Cu Ft	Cu Yards	Liters
1 Dry Pint	1	0 5	0 0625	0 0156	33 6	0 0195	0 00072	0 5506
1 Dry Quart	2	1	0 125	0 0313	67 2	0 0389	0 0014	1 1012
1 Peck	16	8	1	0 250	537 6	0 3111	0 0115	8 8095
1 Bushel U S	64	32	4	1	2 150 4	1 2445	0 0461	35 238
1 Cu Inch	0 0298	0 0149	0 0019	—	1	0 00058	—	0 0164
1 Cu Foot	51 428	25 714	3 214	0 8036	1 728	1	0 037	28 3161
1 Cu Yard	1 388 56	694 28	86 778	21 697	46 656	27	1	764 53
1 Liter	1 816	0 908	0 1135	0 0284	61 026	0 0353	0 0013	1

SELECTED SOURCES OF POULTRY INFORMATION

BOOKS

CARD, L E , and NESHEIM, M C 1966 Poultry Production Lea and Febiger, Philadelphia

EWING, W R 1963 Poultry Nutrition Ray Ewing Co , Pasadena, Calif

HOFSTAD, M S 1972 Diseases of Poultry Iowa State Univ Press, Ames, Iowa

MOUNTNEY, G J 1966 *Poultry Products Technology* Avi Publishing Co , Westport, Conn

PETERSON, E H 1970 Serviceman's Poultry Health Handbook Better Poultry Health Co , Fayetteville, Ark

SCHAIBLE, P J 1970 Poultry Feeds and Nutrition Avi Publishing Co , Westport, Conn

SCOTT, M L , NESHEIM, M C , and YOUNG, R J 1969 Nutrition of Chicken M L Scott and Associates, Ithaca N Y

SENEVIRATNA, P 1969 Diseases of Poultry John Wright & Sons, Bristol, England

STURKIE, P D 1965 Avian Physiology Cornell Univ Press, Ithaca, N Y

TITUS, H W , and FRITZ, J C 1972 The Scientific Feeding of Chickens The Interstate Printers, Danville, Ill

TRADE JOURNALS

AMERICAN POULTRY—521 East 63rd St , Kansas City, Mo , 64110

BROILER INDUSTRY—Garden State Bldg , Sea Island City, N.J 08243

CANADIAN POULTRYMAN—605 Royal Avenue, New Westminister, B C , Canada

CANADIAN POULTRY REVIEW—129 Adelaide St , W Toronto, Ont , Canada

DELMARVA POULTRY AND FARM—The Daily Times, Salisbury, Md , 21801

EGG INDUSTRY—Garden State Bldg , Sea Island City, N.J , 08243

FARM SUPPLIER—Watt Publishing Co , Mount Morris, Ill , 61504

FEED BAG MAGAZINE—152 W Wisconsin Ave , Milwaukee, Wis , 53203

FEED INDUSTRY—Communications Marketing, 5100 Edina Industrial Blvd , Edina, Minn , 55435

FEED MANAGEMENT—Garden State Bldg , Sea Island City, N.J , 08243

FEEDSTUFFS—Miller Publishing Co., P.O. Box 67, Minneapolis, Minn., 55440
INDUSTRIA AVICOLA—Watt Publishing Co., Mount Morris, Ill., 61504
POULTRY AND EGG MARKETING—345 Green St, N.W., Gainesville, Ga., 30501
POULTRY DIGEST—Garden State Bldg., Sea Island City, N J. 08243
POULTRY INTERNATIONAL—Wagenstraat 37, The Hague, Netherlands
POULTRY MEAT—Watt Publishing Co., Mount Morris, Ill, 61054
POULTRY TIMES—308 Spring St, S.W., Gainesville, Ga, 30501
POULTRY TRIBUNE—Watt Publishing Co., Mount Morris, Ill., 61054
POULTRY WORLD—Agricultural Press Ltd., 161 Fleet St, London, England
THE POULTRYMAN—Trade Publishing, Inc., 605 N. Delsea Drive, Vineland, N.J., 08360
THE VIRGINIA POULTRYMAN—Virginia Poultry Federation, 1001 East Main St., Richmond, Va., 23219

SCIENTIFIC JOURNALS

AVIAN DISEASES—University of Massachusetts, Amherst, Mass., 01002
BRITISH POULTRY SCIENCE—Oliver and Boyd Ltd, Tweeddale Ct., 14 High St., Edinburgh, Scotland
JAPANESE POULTRY SCIENCE—Japan Publications Trading Co., P.O. Box 469, Rutland, Vt., 05701
JOURNAL OF HEREDITY—American Genetic Assn, 1507 Main St., N.W., Washington, D.C. 20005
JOURNAL OF NUTRITION—Wistar Institute Press, 3631 Spruce St, Philadelphia, Pa., 19104
POULTRY SCIENCE—Poultry Science Assn, College Station, Tex., 77843
WORLD'S POULTRY SCIENCE—World's Poultry Science Assn., Agricultural House, Knightsbridge, London, S.W.1, England

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